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The literature related to posture research has been predominantly characterized by contradictions in research findings and differing views among authorities. The resulting confusion and misinformation have led some to conclude that relatively little is known about posture. The purpose of this study was to evaluate the nature, cause, and effect of selected problems related to posture research in an effort to interpret the posture literature in a proper perspective and to grasp a better understanding of future approaches to research.

This analytical study of the available literature involved a thorough discussion of the inadequacies of the tools utilized in research, these being: (1) definitions of the product; (2) standards for evaluation; and (3) methods and techniques of measurement. Adverse criticisms of definitions and standards related to fallacies involving the traditional utilization of: (1) the static position to describe a posture that was dynamic in nature; and (2) a narrow stand of postural normalcy which failed to provide for inherited postural differences, varieties of normal due to individual differences in structure and body build. In addition, standards were individually analyzed, questioned as to their usefulness and scientific authenticity. The

qualitative nature of the standardized descriptions involving the relationship of postural components appeared to be of value in subjective estimates of quality posture but of no value in research efforts requiring quantitative evidence. Findings seemed to implicate that the standard, "perpendicular posture," was against nature's way of balancing the body. The line of gravity as a standard was critized because this line of balance apparently failed to take into consideration the phenomenon of body compensation. Because the condition of balance seemed to be satisfied regardless of the quality of posture, the standard referred to as segmental balance likewise appeared to be valueless for evaluating the correctness of posture. The critical analysis of each classification of posture tests also revealed severe problems. Two major limitations of the subjective type tests were discussed, these being: (1) composite scoring; and (2) the element of subjectivity. Objective methods of measurement were criticized as research tools because of: (1) insufficient evidence of scientific authenticity; (2) instrumentation with too many inaccuracies to assure precise and quantitative measurement; and (3) failure to establish quantitative norms to facilitate in the evaluation of test results.

Implications which the writer felt could justifiably be made on the basis of this study were presented. These inferences related to the past, present, and future status of posture research.

A CRITICAL ANALYSIS OF THE PROBLEMS

ENCOUNTERED IN POSTURE RESEARCH

by

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APPROVAL SHEET

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TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

For over half a century, authorities in the fields of physical education and medicine have conducted extensive investigations in an attempt to better understand the upright posture of man. As a result of these years of intensive study, students of posture have at their disposal a massive volume of literature.

It would appear that opinions and research findings of authorities would provide physical educators with a sound, scientific basis for work in the area of posture. On the contrary, the views of these experts, as well as their findings through research, have provided the physical educator with few accurate guidelines for postural definition, measurement and evaluation, and training, and have afforded no justification for the traditional emphasis on programs of posture education.

Miller referred to these fifty years of research efforts by physical educators and orthopedists with these descriptive comments; that among practitioners of both fields, ". . . there is still a seemingly unwarranted lack of agreement. . . . a bewildering lack of unanimity. . . ." (67:89) Wells admitted that we know relatively little about the inherent nature of upright posture; that ". . . there are many things that we believe about it, but few . . . hypotheses have been tested." (73:31) Fox, after discussing a number of problems frequently encountered in the area of posture and body mechanics, made the statement that ". . . after more than half a century, most of the teaching in this area is still based on empirical judgment." (32:315) Wells expressed similar views when she stated, "Since so much emphasis is placed on posture, it is indeed unfortunate that there is so little objective evidence that our efforts are being made in the right direction." (34:365) Darrow commented, "It is hardly necessary to review the chaotic condition of posture today, for the most cursory view cannot fail to convince the observer that something is radically wrong." (13:19)

This writer does not intend to present a review of the "chaotic condition" which exists in the area of posture. Rather, it is the purpose of this study to analyze critically those problems encountered in posture research which this writer believes have led to such a "chaotic condition."

It is the opinion of the author that the "something" that "is radically wrong" are the traditional tools utilized in research as well as the methods of using them. The most important tool of the investigator is the test, constructed and administered for the purpose of obtaining measurable facts. Regardless of how authentic and precise, however, this tool, alone, is not sufficient. Intelligent use is precluded by the establishment of definitive criteria which become the guide lines for evaluation. Such a standard evolves from a precise definition of the product to be measured. In other words, it is only after the investigator is equipped with a definition of product, a standard for evaluation, and a technique for measurement that he can begin to discover, through experimentation, the true nature of the product under consideration. Yet, at the present time, there is no universal agreement among the experts as to the exact meaning of "good" posture. Likewise, no one standard is available that has met the approval of the authorities. Although innumerable tests of posture have been devised, none has been entirely suitable for research work, and many have been totally unsuitable.

It appears that the media for this study, a critical analysis of the problems encountered in posture research, must become an analysis of the problems related to the tools utilized in posture research, these being: (1) definitions of the product; (2) standards for evaluation; and (3) techniques for measurement.

CHAPTER II

POSTURAL CONCEPTS

I. INTRODUCTION

The meaning of the term "good posture" has undergone a number of changes through the years. Variations in concept have been inevitable.

Rasch and Fait noted that postural concepts have been influenced from time to time by esthetic and culturally-determined customs and traditions. (29:367; 15:88) Wells analyzed that a person's idea of what is good or bad posture has depended to a great extent on the nature of the individual's profession, his interest, and his interpretation. (34:353) The resulting situation was described best by Wells when she stated, "There are innumerable concepts of human posture, and innumerable interpretations of its significance. Posture may well claim to be 'all things to all men.'" (34:353)

The one definitive trend of major importance with regard to changing concepts of posture has been a de-emphasis of the static concepts related to erect stance and an increased interest and emphasis in posture dynamics.

II. A REVIEW OF STATIC CONCEPTS

Through the years, good posture has been defined so as to imply a position of erectness that should be maintained by all. Bartels gave an example of this traditional attitude when she quoted an English doctor, Robert Scanes-Spicer. (76) He believed, according to Bartels, that normal posture "'. . . should imply in anatomy a standard of perfection of form and structure to be aimed at. . . .'" (76:25)

The connotation of the "ideal" has found full expression through innumerable definitions which have been proposed as descriptive of optimum upright posture. After reviewing many of these definitions, Massey found that each could be classified as either anatomical or descriptive in nature. (65)

Anatomical Definitions

Anatomical definitions have appeared as two similar but distinct types. Each definition has described correct body position in relationship to a vertical line. The difference between the two types has related to the placement of the vertical line.

Anatomical definitions known as Perpendicular (straight-line) Alignment utilized a standard reference line erected through the center of gravity and the centers of the major weight-bearing segments. The second type was termed Gravity-line Alignment because of its dependence upon the line of gravity, a vertical projection through the center of gravity of the body and its arbitrary relationship to selected body landmarks.

Perpendicular (straight-line) alignment. Brunnstrom, in a study conducted in 1954, made reference to a number of early investigators who described "good" posture in terms of straight-line or vertical alignment. (43:109) It was noted that these early researchers judged a posture as correct if, when viewed from the side, an artificial vertical line could intersect the center of gravity as well as the centers of specified body landmarks. Brunnstrom further explained that these vertically aligned points of reference were usually the tip of the ear, the acromion process, and the centers of the hip, knee, and ankle joints. (43:109)

There is general agreement that this foregoing definition of ideal posture, a concept which came to be called NORMAL-STELLUNG, or "perpendicular posture," originated with the work of Braune and Fischer in 1889. (43; 70; 28; 10) It was noted that Braune and Fischer used frozen cadavers to study the location of the center of gravity of the body as well as the gravity center of each major body segment. Investigators also attempted to study normal segmental angulation as related to the center of gravity of the body as well as the gravity centers of major segments.

Rogers and Brunnstrom pointed out that the use of the NORMAL-STELLUNG as a definition of correct posture was the result of misinterpretation of the intent of its originators. (70:20; 8:283) These writers explained that Braune and Fischer selected the upright standing position and chose to use a vertical line, not because they felt it comparable to good segmental alignment, but because they were in need of a convenient body position and stationary reference from which to analyze. Said Rogers, "It served merely as a statistical point of departure, a line of zero deviation." (70:20) Cooper likewise emphasized that these investigators in no way attempted to establish their NORMAL-STELLUNG as ideal posture. (10:113) Brunnstrom indicated that much of this misinterpretation was probably due to the use of the term, NORMAL-STELLUNG, which means "normal standing." (43:114)

Regardless of the misinterpretation, this concept of rigid, vertical alignment depicting a normal, ideal posture became widespread and was used extensively in posture testing and training. (43:109) Phelps revealed the impact that misinterpretation regarding the work of Braune and Fischer has had when he said, "For several generations a rigid type of posture concept has frozen our thinking." (28:38,59)

Gravity-line alignment. Reynolds and Lovett published a study in 1907 in which they reported the development of a satisfactory method of determining the body's center of gravity in the upright standing position, and the line of gravity as related to the base of support. (68:286) Plans included procedures for establishing the relationship of the line of gravity to selected anatomical landmarks. However, a study of these relationships was never completed by these authors.

A number of definitions of "good" posture have been advanced which were based on the work of Reynolds and Lovett. Definitions of this category have described correct posture anatomically in terms of the relative position of the line of gravity to the base of support and to various body landmarks.

Gravity-line alignment might best be illustrated by reporting the definitions proposed by several authorities who supported the gravity-line approach. Said Basmajian,

> The idealized normal erect posture is one in which the line of gravity drops in the midline between the following bilateral points: (1) the mastoid processes, (2) a point just in front of the shoulder joints, (3) the hip joints (or just behind), (4) a point just in front of the center of the knee joints, and (5) a point just in front of the ankle joints. (5:85,86)

The anatomical definition referred to most frequently by investigators was advanced by Steindler. This authority's view regarding the placement of the gravity line in normal stance was reported as follows:

> It arises from the supporting surface between ball and heel in front of the ankle joint; it runs slightly in front of the knee joint axis: in relaxed posture, through or directly behind the center of the hip joint; then it ascends to cut the upper end of the sacroiliac junction. It then runs upward behind the center of the bodies of the lumbar spine and intersects with the spine at the lumbo-dorsal junction; it continues in front of the dorsal spine and intersects with the spine again at the cervico-dorsal junction. It then runs slightly behind the cervical spine and finally reaches the head behind the ear at the mastoid process. (38:4)

Descriptive Definitions

Two types of descriptive definitions have permeated the literature. Earlier definitions were characterized by a descriptive relationship of selected postural components or elements. A later trend in definitions, descriptive in nature, showed no concern for an exacting relationship of the postural elements but emphasized instead a relative adjustment of body parts to achieve balance among the major segments.

Definitions classified as descriptive were organized for review as: (1) Relationship of postural components; and (2) Balanced postural alignment.

Relationship of postural components. It appears that each authority had his own idea as to the most important components to consider in defining correct stance, the "best" relationship of these postural elements to each other, and how the final concept could best be described.

Massey, after surveying a number of descriptive definitions, found that if definitions were considered individually, a great deal of confusion existed as to the exact meaning of "good" posture. He further noted, however, that a collective consideration of definitions seemed to offer "general agreement" among the authorities as to the postural elements of importance as well as criteria for determining the "best" relationship of the elements. (65:3)

Selected definitions to describe the relationship of postural elements follow. Wells proposed a descriptive definition of good posture with the emphasis that the standing posture as described was a position of reference for all activity postures. Said Wells,

> 1. The total body weight is centered squarely above both feet or else is very slightly forward, but never backward.
> 2. The major weight-bearing segments of the body (the lower extremities, pelvis, trunk, and head) are aligned in a single straight line, either vertical or slanting very slightly forward from the ankles.
> 3. The pelvis is centered squarely above the feet and beneath the trunk, providing firm support for the latter.
> 4. The chest is slightly lifted but the elevation is not forced.
> 5. The head is erect with the profile vertical and the chin level.

6. The feet point forward or slightly outward. In walking they point straight ahead.
7. The ankles, as seen from the front or back, are straight. There is neither pronation (inward sagging), nor supination (exaggerated cupping or arching).
8. The total posture is maintained without evidence of strain or tension. (35:4)

Phelps utilized two descriptive definitions of "good" posture. The first description illustrated the components of "normal" posture, while the second definition described the components of "ideal" or "best" posture. Normal posture was defined in the following manner:

> Part of this theoretically normal posture as has been stated, represents a foot stance, showing variations from a perpendicular heel cord line to one of moderate pronation. The heel cords must be long enough to allow approximately 15 degrees of dorsiflexion of the foot. The knees are straight with no tendency to a back knee position. Five to 10 degrees of hyperextension is possible at the hips without increasing the pelvic inclination. In the normal position the brim of the true pelvis is held to form an angle of 60 to 65 degrees with the supporting surface. The lumbar spine is slightly concave, as measured by a string stretched from the seventh cervical vertebra to the gluteal fold at the sacrum. The dorsal spine presents a slight convexity backwards. The neck is forwardly inclined a slight amount beyond the perpendicular. The shoulders are slightly anterior to the line of gravity from the vertex to the head of the astragalus. There may be a slight left total lateral curvature, usually due to right handedness (70 per cent). The leg lengths are approximately equal. The chest is slightly depressed, and there is enough relaxation of the abdominal musculature to allow a slight prominence of the abdomen. Thus the low back is nearly flat. (28:64,65)

Phelps, in describing "ideal" or "best" posture, emphasized that such a posture was seen only in trained subjects. Said Phelps,

> The foot stance should be such that the line of the heel cord is perpendicular. The knee and hip positions are about the same as in the normal posture. The pelvic inclination is somewhat less (5 degrees approximately) than in the normal posture. The lumbar spine should be flat against a string stretched from the seventh cervical vertebra to the gluteal fold. The dorsal spine should be nearly flat under the string. The chest should be moderately elevated in a position midway between full inspiration and full expiration. The abdominal muscles should be contracted to present a flat surface from the symphysis to the ensiform. The neck line should be relatively perpendicular. The shoulder joints should be in the mid-axillary plane of the body. There should be no lateral curvature. (28:64)

Scott and Morton also contributed worthwile descriptions of "good" posture. (31:417; 27:128)

Massey noted that postural components most frequently referred to by the experts when defining normal posture were: (1) carriage of head and neck; (2) position of chest; (3) curvature of spine; (4) abdominal protuberance; (5) pelvic inclination; and (6) weight distribution at the feet. (65:3)

<u>Balanced postural alignment</u>. Bartels noted that the interest and emphasis of investigators regarding descriptive definitions began to shift in the early 1950's. (76:7) Writers had previously described good standing posture by

verbalizing qualitatively on the relationship of the postural elements considered to be important. After 1950, however, authorities preferred to "individualize" postural stance, to reduce a description of good posture to one of segmental alignment, an alignment whereby each major weight-bearing segment was so located that each balanced vertically upon the one below. (25:118; 2:180; 27:127)

The value which experts attributed to balanced posture were: (1) increased mechanical efficiency; (2) a reduction in the amount of stress imposed on segments; and (3) near-maximum stability. It was thought that these by-products of balanced posture were made possible because the force of gravity was utilized to pull most of the weight directly downward through the bony framework. It was noted that the resulting postural arrangement was favorable to function because muscles and ligaments, now relieved of excessive work and strain, had only to execute the minimal amount of effort to support or balance their respective segment or segments. (27:127; 25:118; 2:180; 7:272)

Several of the available definitions were selected and reported to further clarify this type. Metheny's definition gave special emphasis to the individuality of posture. Said Metheny:

> There is no single best posture for all individuals. Each person must take the body he has and make the best of it. For each person the best posture is that in which the body segments are balanced in the position of least strain and maximum support. This is an individual matter. (25:193)

Wells quoted the definition proposed by McCloy. McCloy stated:

> 'Good posture is that adjustment of the various parts of the whole, in harmony with the individual's bony and ligamentous architecture, which gives the greatest mechanical efficiency, the least interference with organic function, and the greatest freedom from strains.' (35:4)

Among the best descriptions of balanced posture was the definition advocated by the American Posture League. Bowen quoted this definition as follows:

> 'The ideal erect posture is one in which the different segments of the body, head, back, chest, and abdomen, are balanced vertically one upon the other so that the weight is borne mainly by the bony framework, with a minimum of effort and strain on muscles and ligaments; this is when the long axis of its segments, seen in profile, form a vertical line instead of a zigzag.' (7:272, 273)

III. AN ANALYSIS OF THE STATIC APPROACH TO DEFINITION

The realization that definitions become the standards for measurement as well as the criteria for training in programs of posture education causes one to recognize the very serious limitations that such narrow and static concepts impose.

A number of profound criticisms have been rendered against all concepts that are static in nature. Most of these criticisms have been based upon the awareness that all of life involves movement, movement in which the organism is constantly adjusting itself to both internal and external demands; (70:24) that " . . . the organism assumes and maintains a large number of postures from which movement starts and ends." (14:53)

Wells spoke of the term posture as denoting position at any one time. She claimed that because the body is multi-segmented and, therefore, capable of assuming a variety of postures, activity postures as well as variations of the erect standing position, characteristic posture patterns of an individual would be difficult, perhaps impossible, to describe. (34:354, 355)

Rasch, Bowen, and Metheny emphasized that the individual remains in a static or stationary position for a relatively short period of time; that activities of the day, dynamic in nature, require the individual to assume a variety of dynamic postures. (29:393; 7:272; 25:95) Rasch pointed out that ". . . a rigid position is impossible for dynamic balance skills, and the performer or coach who emphasizes rigidity is predestined to failure." (29:128)

Many have advocated the great need for a dynamic approach to posture training as opposed to the traditional emphasis on stationary standing. Cratty questioned ". . . traditional physical education preparation where primary emphasis is given to human motion in mechanical, anatomical, and physiological terms." (11:vii) Scott pointed out that the ability to stand well does not necessarily mean that one can move well. (31:414) Bowen concurred and further emphasized that programs of posture education, in order to realize value, must enlarge in nature and scope to include training in dynamic movement. (7:272) Willgoose and Rasch also advocated the dynamic approach to training with special emphasis upon mechanics of fundamental skills of movement as well as skills encountered in daily occupation. (36:188; 29:69) Metheny clarified the importance of the carry-over effects of static training into dynamic living. Said Metheny, "The important problem of posture . . . is not how to balance the body efficiently in the erect standing position, but how to maintain this efficiency and grace as the body moves through the work and play of a twenty-four-hour day." (25:95)

IV. A REVIEW OF DYNAMIC CONCEPTS

The trend in concept from statics to dynamics has evolved within the past fifteen years. Cooper indicated that this change was ushered in by men such as McCloy, Cureton, Karpovich, and others--persons " . . . interested in the mechanics of human movement." (10:28) These scientists have denounced the traditional standard or "ideal" which belongs to the "mythical average" of the masses. In its place they have proposed definitions that are functional and in the holistic frame of reference--definitions that relate to the total individual in such a way that his posture becomes important in terms of the total being within his total environment.

Recent definitions proposed by various authorities have reflected this change in concept. Williams' concept of "good" posture was presented as follows: "By good postures is meant an adjustment of body parts to each other which result in an erect, alert whole, representing readiness for mental or physical effort." (37:242) His use of the term "postures" is indicative that no single posture is best.

Wells believed " . . . that posture is good or poor, according to how well it meets the demands made upon it.

Good posture means efficient posture, efficient in work, efficient in recreation, and efficient in activities of daily living." (73:32)

Cooper stated, "Normal posture, then, is that posture which best suits the individual in accordance with his own condition and the condition of his environment." (10:115)

Noted Phelps, "Normal posture is difficult to define because of the dynamic aspects, too often forgotten. It is a fluid state, an absence of strain, a near relaxation in the erect stance, that permits graceful movements with the least expenditure of energy. This includes more strenuous physical efforts and is hence a corollary of locomotion." (28:171)

Phelps has continually emphasized the contributions that psychobiologists have made to the concept of dynamics. "Psychobiologists have contributed a moving concept, describing posture as an adjustment chiefly in the erect position (not necessarily standing), as it pertains to problems of locomotion, manipulation, and gestural communications. Maturation and motivation are integrated with learning and skill. Posture is thus a species adjustment to the environment and applies both to the maintained and to the changing relations of different parts of the body to each other and to the supporting media or surface." (28:59)

V. AN ANALYSIS OF THE DYNAMIC APPROACH TO DEFINITION

Selected examples of definitions, dynamic in nature, seem to substantiate the fact that authorities in the area have come to see posture as a manifestation of a constantly changing multisegmented organism, a body possessing not one but many postures.

Williams stressed that posture, as described, is indicative that the goal in posture training is no longer a structural one, that physical educators should now be concerned primarily with efficient, dynamic adjustment. (37:242) Rogers concurred. (70:24)

Said Phelps regarding this trend in definition, "The concepts proposed may be considered beginnings toward a better appreciation of the multiple factors encountered when defining a fluid, dynamic, holistic state of being such as posture." (28:55)

In light of the changing concept, several researchers have criticized the continued use of static tests to evaluate postures that are dynamic in nature. (18;61) The critics have re-emphasized the problems previously discussed. Their main criticism has been aimed at the falaciousness of judging a body with many postures by only one posture--the standing.

Said Jones in regard to this,

> Instantaneous photography upon which most studies of upright posture are based, can supply the index of this relationship at any one moment. The pose of the subject can be standardized; and linear and angular measurements can be obtained by use of various anatomical landmarks. Instantaneous photography, however, does not indicate either the direction or the rate of postural change. It eliminates time from the record and gives no information about the movement from which it is a preparation. To obtain a satisfying expression of dynamic posture, it is necessary to record in time as well as in space. (61:287)

It appears from previous discussions that many investigators have recognized the fallaciousness of the static approach to posture research and have come to accept the dynamic concept of posture. However, in terms of posture research, investigators have also recognized that change in concept from statics to dynamics has presented serious problems.

It was previously stated that posture standards, essential for measurement, depended upon the concept of what the phenomenon should be. Yet, at the present time there appears to be no standard available for evaluating objectively the efficiency of functional posture. (24:257) It further appears that no one standard or set of criteria could be derived from these definitions descriptive of such a variable concept. In other words, dynamic definitions, as presently stated, do not lend themselves to measurement; for dynamic definitions make no quantitative or measurable value judgment as to what is either good or bad posture.

The methods of measurement, when considered in light of the dynamic concept, have created additional problems. Ideally, there should be objective measurement techniques which permit evaluation of the desired concept. In reviewing the literature, however, there seem to be no objective tests for quantitatively evaluating the quality of the segmental alignment of the body in motion. Fox noted that although the dynamic aspects of body mechanics are of greatest concern to us, functional posture, because it is constantly changing, is much more difficult to measure than a stationary or static one. (32:318) Several rating scales of a subjective, qualitative nature have been devised to evaluate the quality of functional posture. For research purposes, however, such techniques would appear to be valueless.

It appears that although criticisms have been justifiable, the researcher, involved in a study of posture requiring quantitative scientific measurement, has no choice but to remain bound to the static upright position.

VI. JUSTIFICATION FOR USE OF THE STATIC STANCE IN POSTURE RESEARCH

A number of authorities, although recognizing the severe limitations of the static posture, have attempted to justify the use of this concept. Wells, Metheny and Daniels, to mention a few authorities, considered the use of the static approach to measurement justifiable as long as the static posture would be thought of as a basic position from which all other postures evolve. (35; 25; 12)

Bartels stated that it " . . . seems fundamental to assume that we must first know how to maintain good static alignment before attention is devoted to the dynamic aspects." (76:7)

Wells and Scott felt that the characteristics prevalent in the dynamic posture would be evidenced to some degree through analysis of static posture. (34; 30) Wells emphasized, however, that such an approach to evaluation would be of value only to the extent that the static posture so tested would represent habitual posture. (34:355)

Rasch felt that the static concept would be significant if used " . . . to simplify and clarify explanations of postural mechanisms." (29:393) He believed that understandings gained in this manner could then be utilized where possible in the study of dynamics. Rasch emphasized strongly, however, that " . . . the student should never be misled into forming a static concept of postural relationships." (29:393)

CHAPTER III

POSTURAL STANDARDS

I. INTRODUCTION

A standard might best be defined as a set of criteria which formalize and idealize the state of postural normalcy. In essence, the criterion becomes a standard guide to refer to, a frame of reference which facilitates the researcher in evaluating the quality of the posture under consideration.

Available standards have originated from the concepts of what the phenomenon should be. Mathews emphasized that the basis for formulating a norm or standard for evaluating posture has been the collective opinions of the experts. (23) In other words, the concepts proposed by authorities in their definitions of good posture indicate ". . . the norm or standard upon which we base our measurement." (23:234)

The significance of posture standards in research has been recognized for a number of years. Authorities in the area of tests and measurement have considered the establishment of a standard of normalcy as pre-requisite to the process of testing. They have known that the use of well defined criteria as a basis for judgment increases the validity, reliability, and objectivity of testing. (36; 9; 23)

II. A REVIEW OF STANDARDS

It has been noted that standards utilized in posture research have evolved from opinionated concepts of postural normalcy. In presenting postural standards, therefore, the writer chose to follow the same classification as was used in reporting postural concepts.

Perpendicular (straight-line) Alignment

One of the earliest standards to be proposed, the Perpendicular (straight-line) Alignment standard, evolved from the previously discussed concept of normal upright posture introduced by Braune and Fischer. This concept and the resulting standard described a rigidly, upright posture so aligned that a straight and perpendicular line, when drawn down the side of the body from the head to the foot, passed through the center of gravity and designated landmarks. As was mentioned previously, the body landmarks, centrally located along the frontal plane of the body, were usually: (1) tip of ear; (2) acromion process; (3) tip of the greater trochanter; (4) center of knee joint; and (5) center of ankle joint. (43:114)

Willgoose indicated that faulty posture, as judged by this standard, depended upon the amount of segmental deviation from the vertical reference line erected through the frontal plane of the body. (36:190) Brunnstrom indicated that the "perpendicular posture" standard has become widely accepted and is being taught in many of the schools to students in physical education and therapy. This writer listed several investigators who have recently advocated the use of the plumbline and the Perpendicular-line standard for posture evaluation. These were: (1) DeLorme (1951); (2) Haddan (1952); and (3) Hashiba (1951). (43:109)

<u>Gravity-line Alignment</u>

Discussions concerning the line of gravity, a vertical projection of the center of gravity of the body, appeared in the literature as early as 1889. (43) However, the idea of using the gravity line as a standard for evaluating the efficiency of erect posture did not appear until 1908 with the work of Reynolds and Lovett. (68) In 1912, Lovett stated,

> It is evident that any reliable method of analysis must take into account the base of support

> and the line of gravity in order to correctly represent the normal standing position as seen from the side. (21:172, 173)

The gravity line as a standard was used extensively in research after 1929, when Steindler defined good posture in terms of the vertical projection of the center of gravity.

Massey made a study of anatomical definitions of this type. He proposed the following definition as a standard of normalcy because of its comprehensive representation of the definitions advanced by authorities.

> . . . beginning approximately at the atlanto-occipital articulation or externally behind the ear at the mastoid process, the vertebrae of the neck, intersecting the spine near the seventh cervical vertebra, passes anteriorly to the dorsal vertebrae, touches the spine again at the lumbo-sacral junction, passes behind the lumbar spine, passes in front of the sacro-iliac junction to the center of the hip joint, then passes in front of the knee joint and drops to the base of support at the feet directly in front of the ankle joint. (65:4)

Brunnstrom, Kendall, Lowman, and Williams, to mention a few, supported the gravity-line approach for defining and measuring the normal standing position. (8; 19; 22; 38)

Relationship of Postural Components

The descriptive standard depicting the best relationship of the postural components might best be described as a verbal picture of the culturally accepted ideal. Innumerable definitions have appeared in the literature in which writers have described the upright stance in terms of elements or components thought to be characteristic of good posture.

A number of definitions of this type were analyzed and synthesized by Massey in 1943. (65) Massey reported the proposed descriptive elements of good posture that authorities seemed to agree upon. Because this investigator's work was based on the collective opinions of the experts, Massey's report became, according to Mathews, a descriptive standard of much importance in evaluation. (23) This standard was stated by Massey in the following manner:

> The principle segments of the body should be balanced evenly over the base of support. The feet are slightly separated, the toes pointed straight forward or slightly outward, the weight of the body is borne mainly over the middle of the foot. There is easy extension of the knee and hips. There should be such position of the pelvic bones as will balance the weight directly over the acetabula, the spine functioning as a poised column with the weight distributed about it. This involves the preservation of a moderate curve in the lumbar region and an easy backward position of the shoulders, to bring the weight upon the spine rather than upon the chest. In this position the shoulder blades are approximately flat, the chest is carried moderately high but not thrust forward, and there is normal tonus of the abdominal muscles. The erect head also balances easily without backward tension or forward stretch. The position is alert and the individual capable of movement in any direction. The position does not represent an

> artificial, arbitrary, or complex combination of postural adjustments, but the most natural, comfortable, and perfectly poised position that the body can assume in standing. (65: 34)

Balanced Postural Alignment

Erect posture has been described as an alignment of major segments according to the specifications of the principles of stability to yield a balanced posture. Segmental balance, it was believed, would assure the individual of mechanical efficiency with a minimum amount of strain and energy expenditure. It appears that the major standard derived from this descriptive definition might be one of segmental balance; that minor criteria such as mechanical efficiency, a minimum amount of strain, and a minimum amount of energy expenditure might also be utilized as standards for judging the degree of correctness of alignment. This standard might best be presented as follows:

> From a mechanical point of view, 'the ideal erect posture is one in which the different segments of the body, head, neck, chest, and abdomen, are balanced vertically one upon the other so that the weight is borne mainly by the bony framework, with a minimum of effort and strain on muscles and ligaments; this is when the long axis of its segments, seen in profile, form a vertical line instead of a zigzag.' (7:272,273)

III. AN ANALYSIS OF STANDARDS

Interestingly enough, most researchers have never doubted the need and importance of the idea of posture standards. Many have relied upon them heavily as guides to posture testing and evaluation. Yet, at the present time, no one standard of "best" posture has received universal acceptance. (4; 24)

Each investigator has been quick to criticize many aspects of the existing standards of static standing; for each standard has been complicated by many problems. It would seem that a review of these problems might offer some explanation as to why no proposed standard has met the complete approval of the authorities.

General Analysis

Major criticisms seem to erupt from the implication inherent in all standards of an absolute nature. This implication, when related to posture standards of static standing, is best expressed as follows: that all postures, to be correct, must conform to an ideal, to the standard definition of what is good. (24:255; 15:92)

Kendall exposed this traditional attitude toward posture standards when he stated,

> It is recognized that there are variations in body type and size among individuals, and that shape and proportions of the body are factors in weight distribution. Nevertheless, the authors believe that a standard of skeletal alignment can be considered a valid standard for evaluating the posture of any individual regardless of body type or size. (19:5)

Noted Kendall, "The standard posture as used and described in this text refers to an 'ideal' posture rather than an average posture." (19:5)

The innumerable possibilities of individual differences have, on the other hand, caused many to oppose a single standard by which to judge all postures. Rasch and Cooper listed a number of reasons for postural differences found among individuals. (29:117; 10:118) For the purpose of this study, however, the writer felt it sufficient to limit the review of differences to a brief discussion of postural variations due to the influence of differences in body structure and build.

The most extensive research with individual differences in structure and the relative effects upon posture was done by McCloy (66). His studies were based on a subjective analysis of bone as viewed from x-ray. McCloy observed that a wide variety of structural differences could be found in any part of the skeletal framework.

For example, this investigator found situations where vertebrae of the thoracic spine varied in anterior and posterior thickness so that some individuals were forced to assume a round back while others maintained a straight one. He believed these differences to be inherited. (66:54)

Variations have also been found in the design and location of the pelvis as well as in the shape and position of the sacrum in the pelvis. (66; 40) McCloy noted two extremes of hereditary lumbar structure. A flat back group had shallow sacra that were located high and forward in the pelvis and yielded vertical-type lumbar spines. The sway back group had hollow sacra that were located low and far back in the pelvis and exhibited a horizontal type lumbar spine. McCloy's findings led him to conclude that "there is no one standard curvature to which all individuals should conform." (66:50) Biglow studied the lumbosacral structure and junction on skeletons and compared these to X-rays. (40: 27,28) It was noted that sacra varied from shallow to hollow while the lumbosacral angle varied from 9-30 degrees. Metheny summarized that the most common variations found in the lower back were the position of the sacrum and lumbosacral angle. She related these differences to the ability or inability to achieve a tucked position of the pelvic girdle and a resulting flat back, a movement that is given much emphasis in posture correction. (25:192)

Wells investigated two extreme types of spinal contours in college women which she believed to be hereditary. (72) The "anthropoid" spines exhibited predominantly convex curves that extended forward into the lumbar region while the "humanoid" type spine extended well into the thorax to give the appearance of a concave spine. Neither of these responded well to attempts at correction.

Arnold, Rogers, and McCloy were of the opinion that many of the variations judged to be postural faults have actually been variations in structural design necessitated by inherited structural divergencies. (39; 69; 66)

Arnold believed that variations in structural design, because they were apparently hereditary in nature and could not be changed through treatment by exercise, should be viewed as varieties of normal as opposed to deviations from normal. (39:1059) Rogers concurred. This author further noted that if observable changes did occur due to corrective efforts, the change would only be temporary. (69: 12) McCloy's view, that many postural variations were due to inherited individual differences in structure rather than to poor posture, was based on the evidence gained from X-ray studies: that many of the same differences found in adult skeletons were also noticeable in the cartilaginous skeletons of infants. (66:54)

Several references were found in which variations in posture were attributed to differences in body build. (17; 33; 54; 55)

Frost made a plea for consideration of postural differences due to body build not only when administering posture examinations, but also when training and correcting postures. (54) This writer emphasized:

> It is this factor of individual build that demands a wide range of normal. The long trunk may show long, gradual curves in both the dorsal and lumbar regions, or the lumbar curve may be relatively long and the dorsal proportionally short. The short trunk has a greater tendency to show short sharp curves, or at times, a long dorsal and a proportionately shorter, sharp lumbar. Is there any justifiable basis for believing that this may not be normal for that individual when it is accompanied by good balance, alignment, and muscle tone? (54:91)

The most extensive scientific investigation of the relationship of posture to body build was conducted by Goff. (55) This investigator used a statistically valid sample of 3,400 photographs of army personnel. Photographs were classified into one of four fundamental body types by the Sheldon method of somatotyping as modified by Hooton. These body types were: (1) linear; (2) muscular; (3) fat; and (4) muscular-balanced. Mean lateral tracings were obtained for each photograph as well as for each type. Said Goff regarding the results:

> The final mean orthogram of each body build proved to be astonishingly characteristic of that particular constitutional type. The illustrations speak for themselves and must be considered a normal for that type of person. . . . Each type has its obvious mean and resist well-intentioned efforts to change. The thin, elongated, or linear type cannot assume the posture position of the muscular type; and the balanced type represents good posture, although it presents a less pleasing appearance than the muscular type. (55:118)

Attempts to establish a relationship between posture and body build in women were made by Poley and Brown. (77; 42) Each researcher utilized Sheldon's technique of somatotyping and a modification of the posture test proposed by Howland. Each concluded that for women no significant relationship existed between body build and posture.

The studies by Poley and Brown leave the theory of an existent relationship between posture and build inconclusive. It might be pointed out, however, that the failure of these two investigators to relate posture to build in women may be due to the fact that the Sheldon technique for somatotyping in men might not be applicable for determinations of body types in women. On the other hand, these two studies might have been limited by the fact that the method utilized to analyze postural alignment may not have allowed for the possibility of individual differences due to body build.

Research findings and views regarding individual differences due to structural design and body build seem to offer justification for a number of criticisms that have been advanced against the use of standards. A selected few of these follow.

Phelps criticized the Kendall standard as ". . . a tall order and not entirely compatible with natural conditions." (28:58) Said Goldthwait, "There is not and cannot be one posture which is normal for all individuals and to which all individuals should conform." (17:38) Wells and Metheny concurred. (34; 25) Wells noted that ". . . due to heredity or to early environmental influences, there can be no single detailed description of good posture." (34:367) Metheny stressed the individuality of posture when she emphasized, "There is no single best position for all individuals. Each person must take the body he has and make the best of it." (25:193) Said Rasch, "Whatever the value of a prescribed posture, expecting everyone to meet any given standard is to ignore the fact that posture is largely an individual matter." (29:329)

Goff, after analyzing the "orthograms" developed in his study of posture and body type, concluded:

> Only one type, the muscular, represents our formerly considered 'ideal posture' stance. The other types, apparently, cannot normally assume such a stance; it follows, therefore, that one should not expect them to do so. (55:118)

McCloy, in discussing the problems related to establishing posture standards, made this statement:

> The devisers of most of the existing standards have apparently assumed that there is one best posture applicable to everyone. There is considerable evidence available that this assumption is not in accord with the facts. There are individual differences in skeletal architecture and in build that would seem to make imperative the establishment of standards in accordance with those differences. (24:255)

It was pointed out by Barrow and McCloy, however, that at the present time no posture definition or standard has been developed which takes into consideration these varieties of normal due to the bony architecture and build. (4:128; 24:257) Mathews stressed, on the other hand, that "Because of this uniqueness of body structure, it not only becomes difficult to establish definitive standards, but it may actually be against the best interest of the individual to do so." (23:235)

Analysis of Individual Standards

To the knowledge of this writer, no postural standard has been thoroughly subjected to the techniques of scientific investigation. Yet, there is sufficient evidence to permit one to question the value of the types of standards which have been used in posture research. A brief discussion follows of the research findings and views of experts which appear to contribute to the analysis of postural standards.

No attempt has been made to evaluate the type of descriptive standard which portrays postural normalcy in terms of the relative position of the body parts to each other. Criteria of this nature have been omitted due to the fact that such standards lend themselves to subjective evaluation but are of no value in a mechanical or quantitative analysis of posture. (33:227) An attempt has been made, however, to analyze the Perpendicular-line standard, the Gravity-line standard, and the standard classified as Balanced Postural Alignment. It was felt that these standards could best be evaluated if the analysis was based on established facts concerning the nature of erect stance in regard to stability.

Stability of the upright stance. Due to structural design as well as unfavorable conditions of the environment, upright posture is plagued with continuous problems of stability. Yet, the body is able to maintain an arrangement of segments that is characteristically balanced, a balance within the body as a whole as well as a balance of major segments in their relationship to each other.

The degree of stability of any object depends upon three criteria. Kinesiologists have listed these principles as follows: that stability is increased proportionately as the center of gravity is lowered, as the base of support is enlarged, and as the line of gravity is brought closer to the center of the supporting base. (34:340,341; 8:268)

Authorities are in agreement that the nature of the structural design of the body offers little in the way of stability when analyzed in terms of the first two criteria. Man's vertical structure demands a relatively high center of gravity. At the same time, this high vertical structure must be supported by a comparatively narrow base of ground support. However, the requirement of stability as specified by the third criterion seems to be satisfied. (8; 34; 29) For example, Hellebrandt demonstrated that although the center of gravity shifted constantly above the base of support, the oscillations were always confined within the limits of the base of support; that for every subject studied, the average location of the center of gravity to the base of support was always close to the geometric center of the supporting base. (59:471) The phenomenon responsible for this "reasonable degree of stability" or balance is an intricate neuromuscular mechanism, a continuous muscular action which makes "unremitting adjustments and counteradjustments of position" in order to keep the gravity line near the center of the base of support. (29:27)

Phelps has pointed out that the principles of stability, as discussed above, are applicable only to the extent that they can relate to "non-rigid bodies in unstable equilibrium." (28:80) It is essential, therefore, that the stability of upright posture should be interpreted in light of certain other known facts, these being:

(1) that the human framework, being multi-segmented and capable of a variety of movements, can assume innumerable positions. (34:354)

(2) that, therefore, the body contains not just one major supporting base, the feet (and the area between), but a number of supporting structures (legs, pelvis, spine). (28:80)

(3) that each base formed by each major segment for support of adjoining segments above is not a rigid support. (28:80)

(4) that total structure will have a center of gravity that is no less important in maintaining balance in relation to the ground base of support. (10:100)

(5) but that nature provides each additional segment with a center of gravity of its own. (25:108)

(6) that stability is no longer dependent solely upon the vertical balance of the center of gravity of the body over the geometric center of the base of support.

(7) that optimum stability is also dependent upon the balance relationship of each of the centers of gravity of each major weight-bearing segment.

Steindler listed requirements which had to be met by multisegmented systems as characterized above, if a state of equilibrium was to be maintained and rotary components of the gravitational forces were to be reduced to zero. According to this writer, the condition of equilibrium for a multisegmented structure required that:

(1) all respective centers of gravity of the individual links, and
(2) all centers of motion fall in the line of gravity.
(3) That this common line of gravity of the whole system falls into the area of support. (33:106, 107)

Steindler noted that the resulting state of passive equilibrium was impossible in the human body because of its structure and construction. Explained Steindler,

> Neither all of the centers of gravity of the different parts nor all the centers of motion between the different parts can be brought to coincide with the common line of gravity. Most

> of the joint centers are, in fact, at a considerable distance from the weight line. Hence, in the upright standing position the force of gravity develops active rotary components in many joints. (33:107)

Steindler further explained that stable equilibrium could be maintained, that the position of body parts could remain, only if rotary components could be neutralized by opposing muscular forces. (33:107) Rasch, in describing stable equilibrium as related to static standing, likewise emphasized that because of rotary components, conditions of such a state could rarely if ever be met. Because the position of the body would constantly change, he chose to describe the stability of the upright posture as a state of dynamic equilibrium. (29:127)

Metheny and Wells applied these latter principles of stability to practical posture work. Their applications have obviously explained the basis for the evolution of common postural faults and the resulting compensation for balance evidently involved. (25; 34) Metheny noted that " . . . should the line of gravity of one part move beyond the edge of the supporting base, the balance of the whole body will be lost unless some other part is moved out of line in the opposite direction. . . ." (25:111) Stated Wells, "When one segment gets out of line, there is usually a compensatory disalignment of another segment in order to maintain a balanced position of the body as a whole. (In other words, for every 'zig' there is a 'zag.'") (34:20)

Perpendicular (straight-line) alignment. As was mentioned previously, Braune and Fischer (1889) had utilized the term NORMAL-STELLUNG (normal standing) to describe a position in which a plumbline intersected the center of gravity of the body as well as the tip of the ear, the acromion process, and the centers of the hip, knee, and ankle joints. (43:109)

The NORMAL-STELLUNG, a position selected by the originators solely for the purpose of measurement and computation, has had a great impact on concepts of postural normalcy and posture research. (8:283) Brunnstrom found the influence difficult to believe, especially since he was able to locate a number of early studies which contained illustrations indicating a slight forward lean with the line of gravity falling anterior to the ankle joint. (43:112) Brunnstrom speculated that the thinking of the investigators who have misinterpreted and misused the concept of "perpendicular posture" might have progressed as follows:

> If all the weight bearing joints are in alignment and the body masses above these joints are balanced vertically above them, a minimum amount of muscular action is needed to maintain the erect standing position. This must be considered the best posture. (43:109)

It was noted in the foregoing discussion of stability that the structure and construction of the multisegmented human organism calls for an "automatic position" of the body in order that the weight line can remain close to the center of the base of support. (43:114) A number of investigators have provided substantial scientific evidence that the placement of the weight line is relative to the degree of body lean; that because most subjects normally stand with a slight forward body lean, the normal placement of the weight line is forward of the ankle joint. For example, Steindler placed the line of gravity 4 cm. in front of the ankle joint while Hellebrandt found the anterior location to be 5.08 cm. (33: 106 ; 60:478) Fox, on the other hand, found that the gravity line fell .95 cm. forward of the anterior border of the tibia. (52:284)

Brunnstrom analyzed that the "perpendicular posture" described by Braune and Fischer could be assumed only if the subject shifts the body weight somewhat backward until a plumbline through the center of gravity falls directly through the axis of the talocrual joints." (8:283)

In other words, Perpendicular (straight-line) Alignment, as a standard of postural normalcy, is false in that the standard can only relate to rigid bodies in stable equilibrium, a situation that is totally incompatible to the multisegmented structure of the human body, a structure that is able to maintain only a dynamic state of equilibrium.

A number of critical comments have been directed against the "perpendicular posture" standard as a result of the later findings regarding the location of the gravity line to the ankle joint. For example, Davis and Logan referred to "perpendicular posture" as a ". . . stiff standing position which purports to obliterate all spinal curves." (14:53) Cooper called it ". . . an unnatural position of immobility." (10:119) Kendall termed the position as "unstable," as a "rigid disciplinary measure," as a position that could ". . . be held only momentarily in the presence of normal external stresses." (19:6) Brunnstrom emphasized that such a position as straight-lined posture was ". . . never assumed by a person who stands in a natural manner." (43:109) He further described the posture as a position that ". . . does not coincide with nature's way of balancing the body." (8:283)

Rasch and Phelps criticized the procedure of applying to live subjects the findings determined from a study of cadavers. (29; 28) Rasch related a statement made by Rudolf A. Fick (1866-1939) regarding the work of Braune and

Fischer. Fick had concluded that the theory of NORMAL-STELLUNG was invalid in that "the recumbent position of a cadaver could not be transferred to the vertical stance." (29:28) Phelps noted that this approach caused problems that were "mechanical" in nature. (28:83)

Although the concept of "perpendicular posture" has long been proven to be a false criterion of "ideal" standing, Brunnstrom noted that this standard of normalcy is still taught to students of posture. The investigator also cited three studies, each conducted early in the 1950's, which used the "perpendicular posture" as a standard for measurement and evaluation of anterior-posture. (43:109)

Gravity-line alignment. The line of gravity has, for many years, been considered of significant value as a standard line of reference for evaluating the quality of body stance and alignment.

As was mentioned previously, Steindler defined normal posture in mechanical terms by describing the position of the line of gravity to the base of support as well as the relationship of this vertical projection of the center of gravity to selected reference points above the base of support. Steindler believed that the line of gravity would, for must subjects, consistently pass through the same designated areas of the spinal column. He called these points of reference "conventional levels" and listed them as being the cervico-dorsal, the dorsolumbar, and the lumbosacral junction. (33:227) Additional points of reference were also described in relation to the weight line. Steindler's definition of normal posture became the anatomical standard most frequently referred to by researchers and teachers in the area of posture.

At the present time, there is considerable disagreement as to the value of using the gravity line as a standard of reference for evaluating anterior-posterior posture. It appears that conflicting views will remain until the standard is scientifically scrutinized, until quantitative studies have been made for the purpose of establishing a valid relationship between the weight line, external body landmarks, and optimum anterior-posterior posture.

The futile attempts to devise a diagnostic posture test by determining the location of the line of gravity as related to the base of support and by establishing the relationship of this to anterior-posterior posture will be discussed extensively in Chapter IV. For the purposes of this section, however, it would appear sufficient to re-emphasize that although the center of gravity shifts with each minute change in body position, the line of gravity will always oscillate within a relatively small area of the base of support. (57:471) For example, Wells, in an informal class experiment, had subjects assume a variety of positions with the upper trunk while simultaneously determining the center of gravity and the line of gravity at the supporting base. (34) It was found that no noticeable change occurred in the location of the line of gravity relative to the base of support, regardless of the position assumed. Wells suggested, "This would seem to provide evidence of the body's tendency to compensate for deviations of some of its parts from the fundamental standing position." (34:357)

In other words, regardless of the posture, the location of the line of gravity to the base of support is relatively stable. Because of this known fact, it would seem that a measurement which locates the gravity-line at the base of support cannot be utilized to differentiate between measurable qualities of anterior-posterior posture. Research findings also seem to indicate that the relative position of this line of reference as measured at the supporting base is unaffected by individual differences due to body build. (73: 31) Neither Cureton nor Brown were able to obtain a significant relationship between the weight line at the base of support and body build. (48; 42)

It would seem that the proper procedure for scientifically scrutinizing the line of gravity as a valid standard for evaluating the quality of anterior-posterior posture must first involve quantitative studies to reveal, for normal posture, the relationship between the weight line and a number of selected points of reference above the supporting base. Fox believed that if valid determinations could be made for the location of the line of gravity for optimum posture, the next logical step would be the development of a posture test that could measure deviations from the desired position. (30:316)

Only a few attempts have been made to locate the gravity line to selected bony landmarks above the ankle joint. Fox and Young conducted an extensive investigation of the location of the line of gravity in anterior-posterior posture to points of reference designated at the base of support and above. (52) In a majority of the subjects, the line of gravity at the knee was found to pass through the patella and, therefore, in front of the knee joint. The line of gravity at the shoulder joint projected through the acromion processes in over half of the subjects. In sixty per cent of the subjects, the gravity line fell through the lobe of the ear or anterior to it. (52:283) The investigators noted that the postures of subjects of this group were usually well balanced and free of overhang or lordosis. They further noted, however, that in cases where the gravity line fell behind the ear, subjects had a distinct forward head. (52:284)

The findings of Fox and Young regarding the placement of the line of gravity to the acromion process and tip of the ear were in agreement with the views of a number of authorities. Phelps, on the other hand, criticized the placement of the gravity line through the shoulder joint to the tip of the ear. He believed a vertical relationship between these two points of reference was valueless because of the mobility of the shoulder girdle. (28:118)

Wells conducted a small experiment as a student at Wellesley college in which she attempted to analyze the relationship between the gravity line and several of the traditional landmarks. (71) This investigator found that the horizontal distance from the line of gravity to each selected landmark varied considerably from subject to subject. Wells reported her findings as follows:

<u>Distance from Line of Gravity to</u>:

Ankle joint	3.80 cm. in front to 6.65 cm. in front
Knee joint	0.46 cm. behind to 2.85 cm. in front

Hip joint .... 6.65 cm. behind to 0.95 cm. in front

Shoulder joint .... 1.80 cm. behind to 6.65 cm. in front

Mastoid process ... 0.95 cm. behind to 5.23 cm. in front. (34:358)

Wells attributed this wide range not only to the difficulty of locating bony landmarks by observation palpation but also to body sway. Wells suggested one possibility for making allowances for sway. She reasoned that since individuals tend to sway in a fairly uniform pattern and since the line of gravity oscillates within a relatively small area of the base of support, a vertical zone might be determined which could be used as an area of reference for the suggested landmarks. (34:358) Hellebrandt criticized the use of any vertical standard for evaluating posture because of the variability due to body sway. (58)

More studies are needed in an effort to establish the relationship of the line of gravity to landmarks in normal stance. These studies should also include determinations for the line of gravity as it relates to the spinal column. At the present time, no scientific investigation has been made of this most important relationship--the relationship of the gravity line to the spinal column.

It appears to this writer that the research in this area is insufficient; that the available findings provide no scientific justification of the validity of the line of gravity as a standard of optimum posture.

Balanced segmental alignment. The descriptive definition, Balanced Segmental Alignment, is, by itself, insufficient as a standard for evaluating optimum stance posture. McCloy explained, however, that "If it were possible to measure segmental poise and balance accurately, these measurements would probably be excellent relative to posture." (24:257) It would appear from this statement that McCloy believed a measure of "segmental poise and balance" could be a satisfactory standard for judging "best" posture if tests were available to evaluate such a condition.

This writer is of the opinion that segmental balance would be of no value as a standard for posture evaluation. From the discussion regarding postural stability, it appears that segmental balance is a condition which exists in posture regardless of the quality of stance; that balance would be present in the alignment of body segments depicting the traditional concept of good posture; but, that balance would also be present in the "fatigue slump." In other words, "segmental poise and balance," as a criterion of good posture, might fail ". . . to recognize the effective compensatory adjustments made by the body in its attempt to maintain balanced alignment." (51:144)

CHAPTER IV

POSTURE MEASUREMENT AND EVALUATION

I. INTRODUCTION

For many years physical educators have attempted to devise and utilize various methods and techniques of measurement in an effort to evaluate scientifically the nature of the upright stance. Glassow noted that attempts were made to grade antero-posterior posture as early as 1890. (16) An indication of the emphasis given to posture testing in the field of physical education was clearly illustrated by Glassow when she related, "No other skill (posture may be considered an achievement in skill) has held the attention of the profession for so long a period; on no other test have greater amounts of time and energy been expended." (16:222)

There appear to be a number of explanations for the emphasis and importance that have been placed on measurement and evaluation of posture. A basic reason is the fact that the "ability to stand well" has remained one of the oldest objectives of the physical education program. In an attempt to carry out this objective, physical educators established extensive programs for posture education and training. Methods and techniques of measurement and evaluation thus became essential.

Physical educators were primarily interested in testing to evaluate individual postures to determine the quality of stance. Such examinations permitted the educator to ascertain not only postures which could be classified as normal but also to detect deviations from the normal. These determinations were essential in order that effective programs of posture education could be set up and in order that corrective exercises could be scientifically prescribed in accordance with individual needs.

Evaluation assumed a great importance when the technique of testing permitted a permanent method for graphically recording results. Re-tests were then possible. In addition, a comparison of results could be made to determine the extent of change or student progress, to evaluate the effectiveness of the exercise program, and to determine the extent to which the program objectives were being met.

The objectives of posture measurement and evaluation were not limited solely to the basic demands inherent in a program of posture training. Investigators also utilized the many techniques of testing in an effort to gain further knowledge and insight into the nature of upright posture. These efforts were essential if programs of posture education and training were to have meaning.

A great deal of the research to reveal the nature of upright posture has evolved out of an "analytical study of body segments and their habitual positions anatomically in order to determine specific relationships or segmental alignment." (65:8) The results of this type of analysis often have been utilized to clarify and define "the normal stance."

Through the years the studies of "the normal stance" have been conducted in an attempt to establish a correlation between "good" posture and health, fitness, and mental and physical ability. However, a knowledge of what is the most advantageous posture, physiologically and mentally, has not been the only question of concern. Investigators have also studied "the normal stance" in an effort to understand better those factors responsible for its maintenance. Such knowledge has led to an awareness of how "good posture" is maintained as well as an understanding of the cause and effect of common postural deviations and a resulting insight into how these might best be corrected.

New findings through posture research have also made investigators aware that many of the views and practices previously adhered to have been unsound. For example, the fact that there are known individual postural differences due to body build and structure should warn the intelligent researcher of the fallacy of utilizing the traditional concept of "the normal stance" when defining "good" posture or when measuring and evaluating posture based on the resulting standard. Recent research findings have been of considerable value, not only because they have revealed the need for changes in techniques of research, but they have also given direction to the route that the needed change should take.

It must be concluded that the importance and emphasis placed upon posture measurement was a normal outcome of the posture program; for physical educators knew that the worth of any program could never be clarified until the effects could be measured and evaluated. Through the years innumerable techniques have been advanced to facilitate in measurement and evaluation of static anterior-posterior posture. Tests have been categorized by measurement experts as subjective or objective.

Tests have been classified as subjective if personal opinions and judgment must be used by the examiner to obtain a score. Cureton explained subjectivity as ". . . the procedure of guessing the grade after visual inspection based upon the opinions of the examiner." (47:82)

Because of major limitations inherent in all subjective tests, a number of authorities gradually attempted to develop more objective posture tests which would meet the requirements of a good research tool.

The major characteristic common to the objective type tests was expressed by Glassow: that it ". . . restricts to narrow limits the errors due to opinion." (16:47) The term, objectivity, was used by Cureton to denote ". . . the procedure of giving a rank position to each subject on the basis of measurements made with accurate and reliable instruments." (47:82)

II. SUBJECTIVE MEASUREMENT AND EVALUATION

Early methods of testing upright posture were subjective in nature. Physical educators made extensive use of subjective methods to ascertain individual needs in programs of posture training. Many of these early tests were also used in research where attempts were made to determine the effectiveness of corrective exercises on posture as well as the relationship of posture to health (longevity, organic functioning, fitness), motor ability, and mental ability.

These techniques have obviously been of no value as research tools; however, the writer felt it necessary to review briefly a selection of these tests. It was felt that such a survey would: (1) clarify the nature of the subjective type; (2) illustrate a few of the inadequacies and limitations; and (3) present the beginnings of posture measurement in order that the reader might better appreciate the progress that posture testing has made through the years.

Review of Subjective Tests

The earliest posture tests involved the use of either the perpendicular-line standard or the gravity-line standard for evaluating static anterior-posterior posture. Such devices as the plumbline or a pole facilitated the examiner in his visual inspection and evaluation of the posture of the individual. Deviations from the standard were noted and became the basis for the assignment of a general posture grade. Tests of this nature were: (1) the Bancroft Vertical Line test; and (2) Lowman's Method of Posture Examination. (3; 22)

Another type of posture test was that developed by Kiphuth. (16:226) The test permitted an evaluation of selected postural components; namely, the position of the head, the position of the shoulders, and the spinal curves.

Subjects were examined from a lateral view using a preconceived idea of what was "normal" for each element. Measurement of each element was accomplished by using selected anatomical points of reference and string. For example, the spinal curves were evaluated by use of a string stretched from the 5th lumbar to the 1st dorsal vertebra. The string was supposed to be straight and to contact all spinous processes.

After the development of the silhouettograph by Fradd, the trend in testing moved from "direct" (visual inspection of subject) to "indirect" (evaluation of pictorial record by comparison to predetermined standard). (53) Development of the silhouette was also the beginning of standardization of normalcy based on the opinions of experts. A number of investigators used expert opinion and scientific procedures to devise sets of silhouettes as pictorial standards or guides to refer to when evaluating profile silhouettes of subjects. Two types of standards evolved.

The first type of standard test consisted of four silhouettes. Each was designed to represent the characteristics thought to be prevalent in either excellent, good, fair, or poor posture. A composite grade of A, B, C, or D was given. An example of a standardized test of this type was that developed by Fradd. (53)

The second category of standards consisted of a series of silhouettes selected and scaled to represent all degrees of postural stance, from very poor to excellent. The Crook Posture Scale, an example of this type of standard, was developed in the same manner as was the Brownell Scale reported in most measurement texts. Crook's standard scale contained thirteen silhouettes, and each was designated a grade. The scale was used by comparing, twice, the silhouettes of subjects with each standard silhouette of the series, each comparison being made from opposite ends of the scale. An average of the comparisons became the posture grade. (45)

Two investigators were able to increase the objectivity of subjectively judging silhouettes by incorporating new techniques into testing. (44; 62) Christenson used a projector to superimpose silhouettes of subjects onto the Brownell Standards. This investigator found that when a direct comparison of the silhouette was made with the Brownell standards "the mean deviation was 26.7 with a range of 90 out of a possible 100." (44:91) However, when the judges evaluated the same silhouettes by superimposing them upon the projected Brownell standards, the range was only 20 with a mean deviation of 2.85. (44) Korb placed an outline of excellent posture (based on over 2,000 subjects) on the backdrop of the photography room so that silhouettes of subjects would be surrounded by a standard of normalcy. (62) Meyer reported that Korb's technique of analysis "increased the validity by almost 50 per cent with 76 judges and favorably affected reliability." (26:270)

Analysis of Subjective Tests

Subjective type tests have been severely criticized by a number of experts. (9; 46; 16) It appears that the most prevalent criticisms have related to: (1) composite scoring; and (2) subjectivity.

Composite scoring. After a visual inspection of the total posture of either the subject or an image of the subject, a single posture grade of A, B, C, or D was usually given. Cureton pointed out that such a system of composite scoring was not very susceptible to accurate statistical analysis; that literally hundreds of records of this type have been filed away because of no meaning. (46:356) Clarke criticized composite scoring as misleading because it did not reveal the true nature of an individual's posture. He emphasized the importance of an evaluation of each aspect of segmental alignment in order to determine the strengths and weaknesses of the body carriage. (9:154)

Subjectivity. The element of subjectivity became the basis for the most severe criticisms of these early tests. Glassow and Cureton pointed out that, when subjective tests were utilized to evaluate and score a postural stance, variability in scoring was relative to the training and experience of the examiners. (16:40) (47:82) However, Cureton further demonstrated that even the careful selection of highly qualified judges might not be sufficient to assure that accurate measures could be obtained. Cureton exposed the major disadvantage of the subjective inspectional scheme over an objective method of evaluation by comparing the results of established subjective and objective posture tests administered by three highly trained investigators who had worked closely with each other for three years. (47:92) He found that the subjective approach gave a result of only 13.4 per cent better than pure chance guesses as an average in ranking pupils. The objective method of evaluation, on the other hand, was found to be four times as good. This scheme raised the mean correlation from .51 to .88. The "r" of .88 carried a predictive index of .45, or 45 per cent better than chance.

In his discussions of subjective measures of posture, Massey related that "In the hands of skilled examiners, the [subjective tests] lend themselves readily to situations where qualitative tests for groups are desired." (65:4) He stressed, however, that because these methods depend upon ratings on the basis of inspection, they are not "accurate enough for research purposes; they permit no permanent or reliable records; and they leave results open to differences in interpretation." (65:4, 5) Massey's concluding statement regarding this matter was as follows: "For purposes requiring careful diagnosis or research, more objective, quantitative, and graphic records are desirable." (65:5) Massey, like others, recognized that the quality of research in any scientific field was dependent upon the integrity of the methods and techniques of measurement utilized.

III. ESSENTIAL CHARACTERISTICS OF A GOOD RESEARCH TOOL

In an effort to promote quality research, investigators, specialists in the field of testing and measuring, have established a number of characteristics felt to be essential standards for any test utilized for the purpose of scientific investigation. Bovard found agreement among authorities regarding the criteria of importance for testing. He noted that standards for measuring techniques usually related to such topics as: (1) validity; (2) reliability; (3) objectivity; (4) administrative efficiency; (5) standard directions; and (6) norms. (6:327)

It was felt that a brief presentation of the characteristics of a good research tool would not only facilitate in evaluating the survey of the tests of posture that will follow, but should also allow the reader to judge the quality of these tests in a proper perspective. Although each of the above characteristics was surveyed to obtain the views of a number of investigators, only four were selected as essential for discussion. These were: (1) validity; (2) reliability; (3) objectivity; and (4) norms.

Validity

Test validity has been defined as the degree to which the proposed test accurately measures what it claims or purports to measure. (23:21; 9:29; 16:30) Meyer stated that a test is valid to the extent that it ". . . indicates the degree to which measurement represents the item or characteristic being considered. . . ." (26:60)

Importance. Authorities have ranked validity as the most important of all the essential characteristics of a good test. (26:60; 6:327) Meyer emphasized that the invalid test ". . . serves no useful function." (26:60) Clarke further clarified Meyer's statement when he stated that ". . . without it one does not know what the test measures. In fact, to use an unvalidated test is worse than useless: it is positively misleading." (9:33) Mathews noted that a test, although high in reliability and objectivity, can still be no better than its validity. (23)

Determination. The validity of a test may be determined by comparing, mathematically, two types of measures: (1) those measurements obtained by administering the proposed test; and (2) the scores of an outside criterion, a sample previously established and accepted as a diagnostic tool which measures the same desired qualities under consideration. (26:60; 6:327; 16:31)

Five statistical procedures have been utilized for establishing the relationship between a proposed test and the selected criterion. Larson listed these tools as: (1) zero order correlation; (2) partial correlation; (3) multiple correlation; (4) causal analysis; and (5) factor analysis. (20:434)

The multiple correlation has been the technique used most frequently by investigators concerned with validating tests of posture. (24:35) The established relationship, known as a coefficient of correlation, would designate the degree to which the correlated scores measure the same qualities. (32:111; 9:30)

Standards for evaluation. Tests utilized for research purposes should be selected on the basis of an acceptable degree of validity. Glassow quoted Garrett's views regarding acceptable standards of validity. Said Garrett,

> Strictly speaking, the term 'high correlation' should be applied only to coefficients which are .95 or above. However, in mental, social and educational measurements there are so many actual and potential sources of error due to the variability of the material dealt with and the relative crudity of measurements made, that very few tests indeed could meet this requirement. Very seldom do correlations between tests run above a .70 or .75; and hence it is probably justifiable, in view of the limitations mentioned, to regard such coefficients as high. (16:32)

Clarke reported that a validity coefficient of .90 and above was the most desirable standard but that tests with a validity of .80 were significant. (9:33) Cureton quoted Franzen's minimum standard acceptable for research as .80. (47:82)

Mathews reported a numerical scale with descriptive comments as a guide for evaluating validity. It appeared as follows:

r = .90 to .99	
r = .80 to .89 . . .	Validity coefficients may be interpreted as very good from .80 to .85 and excellent above .85. . . . Seldom do we obtain a higher than .89 validity coefficient.

r = .70 to .79 . . . quite a number of acceptable validity coefficients may appear in this range. Their worth is dependent upon the complexity of the variables involved.

r = .60 to .69 . . . in more complex tests, such as those for general physical fitness, a validity coefficient falling within this range might be considered acceptable. (23: 22, 23)

Reliability and Objectivity

That a test is capable of measuring that which it claims or purports to measure (validity) is an essential feature but not sufficient. The researcher must also be assured that the test itself is accurate and, therefore, dependable as a measure. Clarke emphasized that "The accuracy with which things are measured, or with which differences are perceived, depends first upon the precision of the measuring instrument." (9:34) Also noted was the fact that differences in an ability to be measured were easy to detect when the differences were of opposite extreme, but that precise measuring instruments were essential in order to determine the amount of difference. (9:34) In other words, a research tool, to be scientifically authentic, must be characterized by precision and refinement so as to yield a given amount of difference with accuracy. Stated Cureton, "The precision of a test is never known until its reliability and objectivity is determined by experiment." (47:82)

Definition of reliability. Glassow stated that "Any testing or measuring device to be a reliable test must always find the same amount of a given element or of a given ability on repeated applications of the measurement." (16:18) Thus, it might be said that reliability of a test reveals the extent to which the test could be depended upon, could be trusted to produce consistent measures of the ability under consideration when administered repeatedly to the identical group of individuals. Bovard, Clarke, Meyer and Mathews concurred with Glassow. (6:329; 9:35; 26:62; 23:20) These investigators also noted that the assumption had to be made that no change would occur in the ability being tested either during the test or in the interim between tests.

Importance of reliability. The importance of assuring that a test meets high standards of reliability might best be illustrated by a discussion of the relationship between reliability and validity.

It was previously stated that a validity coefficient reveals how accurately a test measures what it is supposed to measure, while test reliability is indicative of how accurate the test measures whatever it may measure. (6:329) Meyer regarded reliability as " . . . an aspect or phase of validity." (26:62) Scott, on the other hand, spoke of reliability as " . . . a prerequisite of validity." (32:112)

The importance of reliability rests with the fact that a test will not be highly valid in its measure of ability if the measurement technique itself proves unreliable. (26:62; 32:242) In other words, a test of low reliability will usually result in a test of low validity. A test cannot be valid and unreliable. Stated Scott, " . . . if the test is not consistent in its measurement of a given ability, it cannot be consistent in measurement of that ability represented by the criterion." (32:112) Bovard expressed this same view and enlarged this concept as follows:

> A test which does not correlate more than .6 with itself cannot, except by chance, correlate higher than .6 with anything else except in rather infrequent situations where the reliability of 'anything else' is very much greater than the reliability of the test itself. (6:332)

Scott warned that "when an investigator selects unreliable items, he condemns his efforts at this point. . . ." (32:242)

On the other hand, it must be pointed out that high reliability may not affect validity. A test can be highly reliable but invalid. For example, the examiner may be able to obtain consistent scores on successive trials of a test but the scores may not disclose an accurate picture of the posture under examination. (6:332) In this situation the test ". . . measures what it measures consistently (reliability) but does not measure what it is intended to measure (validity)." (26:62, 63)

Determination of reliability. Three techniques have been applied by test administrators to establish reliability. These were presented by Larson as: (1) the test-retest; (2) split-halves; and (3) parallel forms. (20:434)

It appears that where reliability has been established for tests of posture, the test-retest pattern has been the technique utilized. The test under consideration would be administered on two different occasions, taking precautions that the conditions of the testing situations would be the same. Reliability could then be established by correlating the results of the first testing with those of the second.

The statistical technique applied to establish the degree of relationship between the two variables measured and scored on the test-retest has been the zero order correlation. The resulting mathematical computation, a numerical expression of agreement, has been referred to as the coefficient of correlation. (20:435)

<u>Definition of objectivity</u>. Stated Meyer, "If consistent results are obtained from the use of the same method of measurement by different individuals, then the test possesses objectivity." (26:63) In other words, a test exhibits the characteristics of objectivity to the extent that two or more examiners obtain consistent results after each has administered the same test to the same group of subjects.

Objectivity is closely related to reliability. For example, reliability is established when the scores of a single examiner, obtained on successive administrations of the same test, are compared. It reveals the degree of test dependability. Objectivity, on the other hand, reveals the degree of uniformity between two judges in that it involves a comparison of the scores obtained on the same test by two different examiners.

Stated Meyer, "Whereas reliability is concerned with the consistency of the test itself, objectivity entails consistency of test results obtained by different test administrators." (26:63) Reliability and objectivity, each being a measure of consistency, are, therefore, reflective as to the degree of precision of the test.

Importance of objectivity. Glassow believed objectivity to be an inessential criterion of a "good" test. This authority preferred to accept validity and reliability as the only necessary standards and to interpret the importance of objectivity in light of its influence on reliability. Stated Glassow, ". . .it [objectivity] is important because it is likely to increase the accuracy and the reliability of the scoring." (16:49)

Other test authorities have expressed opposite views regarding test objectivity, however. Cureton indicated its importance when he emphasized that, in addition to reliability, objectivity must also be present in order for a test to be depended upon as precise and therefore accurate. (47:82) Clarke pointed out that objectivity is often calculated in the place of reliability. (9:37) His qualification for the acceptability of such a procedure was based upon the reasoning that should a high degree of objectivity be obtained, a high degree of reliability could be assumed since two examiners were less likely to agree on results than would an examiner with himself. In other words, a test exhibiting a high degree of objectivity would likewise assure that the test is highly reliable.

Mathews offered further support as to the importance of objectivity. (23:21) He advocated that objectivity was a safer indication of agreement. Mathews, aware of the possibility of a single examiner committing an "unknowing" error on the test as well as the retest, emphasized that a test for objectivity would prevent such a situation due to the fact that two examiners would not likely make the same mistake.

Larson warned, however, that "An instrument may yield a high level of reliability in the hands of one examiner and yet have a low level of objectivity." (20:435) In other words, an examiner could possibly agree with self on a test-retest but his decision might not necessarily agree with the decision of others.

Where more than one examiner is involved in the administration of a test for research purposes, it seems of paramount importance that the reliability as well as the objectivity be determined for the test being administered. It appears to this writer that the time consuming task of posture testing would demand, in most cases, the use of more than one examiner; that under these circumstances, the criterion of objectivity should be considered of equal importance with validity and reliability.

<u>Determination of objectivity</u>. The procedure and statistical technique utilized for establishing the degree of test objectivity is the same as that applied to determine test reliability. (32:244)

The pattern of parallel forms is available for use in situations where learning or conditioning results from a particular test. However, the pattern applied to most tests of physical ability, including posture, is the test-retest. (20:435) During the first test of the pattern each examiner evaluates each subject individually utilizing the same procedures for test administration. "The zero order correlation is applied to determine the degree of objectivity, correlating the results gained by Examiner One with those of Examiner Two." (20:435)

Scott has pointed out that should test administrators decide to divide the task of measurement, one being responsible for the evaluation of subjects on the first test and the other examiner assuming the responsibility of the second test, the resulting correlation coefficient would yield a combination of test reliability and test objectivity. (32:244) Scott's remarks regarding this procedure were as follows: "Such a coefficient is hard to interpret, as one cannot be certain what proportion of inconsistency results from the testers' judgment and what part is due to other extraneous factors." (32:244) This authority further suggested, however, that a correlation coefficient designating both the reliability and objectivity of a test is, more than likely, a better indication of accuracy than a correlation coefficient of either of the two alone.

Standards for evaluation of reliability and objectivity. Perfect reliability of a test could be assumed if a test administrator could ". . . always find the same amount of a given element or of a given ability on repeated applications of the measurement." (16:18) Likewise, perfect objectivity of a test could be assured if the test results of one judge, when compared with the scores of a second examiner, showed no disagreement. (9:36)

However, it is improbable and more likely, impossible, that a test of physical ability could ever be devised which would meet these high standards of perfection. Many variables, some which can be controlled but many that remain uncontrollable, play havoc with all aspects of most tests as well as the testing. These variables cause a wide range of fluctuations in scores. Depending on their nature and complexity, they act to reduce both the reliability and the objectivity of a test to various degrees less than perfect.

The fact that perfect test reliability and objectivity are ideals never to be achieved, but only to be strived for, has presented numerous problems to researchers. Paramount is the question, "When can the examiner be assured that the test under consideration has yielded a reliability and/or objectivity that is acceptable to the extent that it can be judged as scientifically authentic and therefore safe for use in research studies?"

Test authorities have attempted to provide answers to this question by establishing criteria as guides for evaluating the quality of the reliability and objectivity of a test. A number of standards in the form of numerical scales have appeared in the literature and have provided the researchers with the needed guidelines for evaluation. The following review contains a survey of scales for evaluating reliability and objectivity which have been proposed or adopted by measurement experts in the field of physical education.

In setting up standards for reliability, test authorities have made a clear distinction between tests used for evaluation of group achievement and those utilized for diagnosis of specific abilities related to the individual (6:332) For example, Scott felt that an "r" of .75 would be a sufficient indication of reliability when concerned with group analysis while a minimum reliability coefficient of .85 would be essential for tests of individual abilities. (32:244) Meyer agreed. (26:63) Larson was in agreement with the standard suggested by Scott in regard to group measurement but believed that an acceptable minimal standard of reliability for individual use should reach at least .90 or above. (20:435)

Because posture evaluation falls within the realm of individual diagnostic testing, standards which have been advocated by authorities as suitable for this type of testing are of most concern to researchers in the area of posture. Glassow noted that a reliability coefficient of .9 was most desirable as a minimal standard for individual measurement. (16:21) However, she further stated that very few tests were in existence which exhibited this high degree of dependability. She believed that a minimum "r" of .8 was acceptable but noted that a test examiner using a test with a reliability coefficient below .8 could not be assured of accurate rankings. Glassow acknowledged that a standard coefficient of .8 was low but that the use of a test exhibiting such a reliability remained superior to any method of subjectively ranking pupils as to ability. (16:21) This authority offered Garrett's standard as support for her views. Stated Garrett, "To be a reliable measure of capacity, a mental or physical test should--generally speaking--have a minimum reliability coefficient of at least .80." (16:21)

Several investigators have formulated standard scales to assist researchers in evaluating the quality of reliability coefficients. Larson's scale of standards appeared as follows:

High = .90 and above;
Moderate = .80 to .90;
Low = below .80. (20:258)

In reporting this scale, Larson noted that the standards ". . . assume careful procedures on administration and are those results which are generally found in field administration." (20:258) An estimate of reliability and objectivity was given for a number of individual ability type tests. It was noted that body mechanics (posture) was rated by Larson as "moderately low" with the comment that the coefficient would vary according to the component being measured. (20:258)

Meyer offered a more descriptive scale for interpreting reliability coefficients.

.90 - .99	High Correlation.
.80 - .89	Good correlation. Satisfactory for individual measurement.

.70 - .79	Fair correlation. Satisfactory for group measurement but generally unsatisfactory for individual measurement.
.69 and below	Poor correlation. Satisfactory for school surveys and group comparisons. (26:63)

Mathews advocated a scale of standards for evaluating reliability very similar to the one proposed by Meyer. (23:22) Glassow and Clarke preferred to rely upon the opinions of Ruch and Stoddard, two authorities in the field of educational measurement and evaluation. (16:22; 9:36) Glassow and Clarke quoted the standards of reliability of these two test experts as follows:

.95 - .99	Very high; rarely found among present tests.
.90 - .94	High; equaled by a few of the best tests.
.80 - .89	Fairly high; fairly adequate for individual measurements.
.70 - .79	Rather low; adequate for group measurement but not very satisfactory for individual measurement.
Below .70	Low; entirely inadequate for individual measurement although useful for group averages and school surveys. (16:22; 9:36)

Glassow and Bovard, although recognizing the necessity, opposed the use of a single numerical standard for evaluating reliability. These authorities stressed that no one standard could be established which would apply to every test. (16; 6)

Glassow believed the degree of reliability to be relative, dependent upon the nature and purpose of the particular test under consideration as well as the size and variability of the subjects. She preferred to judge a test as exhibiting acceptable reliability if, in repeated applications, its measures were in "reasonable agreement." (16:18)

Bovard likewise recognized that reliability depended upon a number of factors variable from test to test. He pointed out that reliability of a test depended not only upon the time involved in testing but also upon the group for which the test was designed. (6:332)

Mathews concurred with the views of Glassow and Bovard. He stated, "Establishing such a standard has its faults, as there are certain exceptions that cannot be taken into consideration by a single scale." (23:22)

Perhaps the opinions of Glassow, Bovard, and Mathews, as presented above, have provided needed explanation for the obvious variability among the scales selected for review in this study. It appears that this discussion offers supporting evidence that universal agreement among test authorities as to a single criterion for judging test reliability will probably never become a reality. One must conclude that whether considered individually or collectively, no numerical standard used for judging the degree of reliability can offer more than a general estimate of the acceptable standards of reliability.

Test authorities in the field of physical education apparently advocate that numerical scales devised for judging the quality of reliability also be used for evaluating objectivity.

The standard scales of Larson and Meyer, reported earlier in this study as criteria for evaluating the quality of reliability coefficients, were also proposed by these authors for use in judging the degree of objectivity. (20; 26) In addition, the descriptive scale advocated by Mathews as a guide for estimating the level of reliability (referred to on page 81) was likewise recommended as a numerical criterion for evaluating the quality of test objectivity. This scale was reported as follows:

r = .90 to .99	Excellent; most tests in physical education should show reliability and objectivity within this range.
r = .80 to .89	Fair; objectivity and reliability coefficients reported within this range, in most cases, would be considered fair.
r = .70 to .79	Poor to Fair; in physical education activity tests, this range would be considered only poor to fair for reliability and objectivity.

r = .60 to .69 Poor; generally speaking, this range of correlations, and those below, would be considered poor. (23:22)

The numerical standards advanced by the test authorities in the general field of educational measurement and evaluation and adopted by two physical education experts, Glassow and Clarke, were evidently proposed solely as criterion scales for judging reliability. (16:22; 9:36) (See page 81.)

Norms

Clarke listed the unavailability of quantitative norms for objective tests of anterior-posterior posture as a major weakness of research in posture measurement and evaluation. (9) He pointed out that the only available norm for an objective posture test was devised by MacEwan for the Wellesley Posture Test, but further noted that the scale was an arbitrary one, ". . . established . . . for over-all posture positions." (9:165)

Regardless, it appears that the advantages rendered by the availability of satisfactory norms for tests justify a discussion of the norm as an important characteristic of a good test of posture.

Definition and importance. An established norm is a standardized quantitative statement of individual or group achievement levels based on test performance scores. (23:23; 26:65) Clarke noted that norms in physical education are usually presented as average scores with standards to " . . . indicate the significance of variances from this point." (9: 38) A norm established for a particular test becomes a guide that indicates the range and quality of performance that can be expected on the test under consideration when administered to an individual or group of subjects identical to the group for which the norm had originally been developed. (26:65; 23:23)

Glassow emphasized that even though previously established norms might not be available, the test could still serve a useful purpose. (16:54) However, measurement experts have recognized that the availability of a test norm facilitates in evaluating the facts obtained through measurement, and, therefore, increases the usefulness of the test. The norm provides additional meaning in that it offers the opportunity to interpret adequately test results. It permits the examiner to make a comparison between test results and the standardized scale of ability for the purpose of determining the quality of individual or group performance scores on the test. (9:38; 23:23; 26:66) That a test administrator could compare the level of achievement of an individual or group with the quality of performance determined for other subjects by the same test is another advantage frequently noted. (23: 23) It would also appear that a large number of records of test results, interpreted in light of quantitative norms, could, in time, be invaluable to experts in the area of posture for establishing a justifiable qualitative statement of postural normalcy. Noted Fox,

> While body alignment varies normally from individual to individual during various periods of growth, there needs to be a limit set beyond which certain body positions would not be considered normal. (30:321)

Determination. Several preliminary steps must be taken when establishing any standardized statement of performance for a given ability. For example, the investigator: (1) must determine if the norm is to be a local, state, or national standard; and (2) must define the group for which the test is intended and for which the norm is to be established. (26:64)

In physical education, norms have usually been based on various combinations of such characteristics as age or grade and sex, height and/or weight so as to be expressed in the form of a classification index. (26:65; 9:38) Where the attempt has been made to establish a norm for a test of posture, the characteristics used as a basis for classification were age or grade and sex. No consideration has been given to body build when constructing either the objective tests of anterior-posterior posture or the norms based on test scores.

A number of procedures must be carefully followed once the group has been adequately defined. For example, the administrator must randomly select a large number of subjects who fit the description of the "defined group." The selection must sample the entire geographical area for which the norms are being established. Care must also be taken that, within the defined geographical area, random sampling of subjects be conducted so as to represent proportion of population as well as a wide distribution of the population. The test under consideration is then administered under carefully controlled conditions to a group of subjects once again randomly selected and for whom the norm is to apply. (9:40,41; 26:64)

Following the collection of data, norms are computed. Scott noted that norms are often ". . . presented simply as a letter grade scale based on equal intervals on the baseline of a normal curve." (30:237)

Clarke and Scott presented the generally recognized and most frequently used scales in physical education which were based upon standard deviation values of normal distribution. These were: (1) standard score scales; (2) T-scales; (3) sigma scales; and (4) Hull-scale. (9:39; 30:237)

McCloy mentioned additional methods utilized for calculating scales of normalcy; that norms may appear in the form of averages (percentiles) or may be " . . . based on an index obtained by the division of the score by the value derived from the multiple regression equation." (24:35)

No attempt will be made in this paper to reiterate all of the information presented by writers mentioned above. It should be noted, however, that each authority compared various combinations of these scales for similarities as well as differences, for advantages as well as disadvantages. Each reviewed the statistical techniques and mathematical computations involved in determining norms.

Standards for evaluation. No numerical scales such as those used for judging the condition of validity, reliability or objectivity are available as guides to evaluate the quality of norms. Rather, the administrator of a particular test must scrutinize the work of the researcher who developed the test and test norm for assurance of the following: (1) that the number of subjects sampled throughout the study, especially for the testing, was large enough to ". . . guarantee desirable accuracy of the normaled scores." (26:65) and (2) that subjects be randomly selected so as to represent the similar population at large. (26:65) Mathews and Bovard concurred. (23:23; 6:335) Emphasized Bovard,

> . . . mere numbers do not produce good norms. Adequate sampling plus a sufficient number of cases to reduce the standard error or estimate to a negligible quantity are the keynotes of good norms. (6:335)

It must be noted, however, that no author made a commitment as to what would be considered a sufficient number of cases. In addition to the above two criteria, random sampling and a sufficient number of cases, Meyer stressed the importance of the administrator also assuring similarity between the group to be tested and the defined group for which the norm was designed. (26:65)

Meyer believed that norms ". . . furnish a reliable (accurate) and useful basis for interpretation and application of test results." (26:66) However, he stressed that such a value is relative ". . . to the extent that the sampling is truly representative and conditions affecting the administration of the test are rigidly duplicated." (26:66) Meyer further noted that should norms accompanying a test fail to ". . . reflect an accurate picture of typical accomplishment, they are not only useless but in reality deceitful." (26:64)

IV. OBJECTIVE MEASUREMENT AND EVALUATION

A review and analysis of selected objective anterior-posterior posture tests follow. It was felt that selected posture tests, if analyzed in light of proposed test criteria, might: (1) offer some insight into the strengths and weaknesses of the available tests; (2) engender a better understanding of the reasons for the "chaotic condition" of posture research; (3) give a better basis for which to interpret the research findings available, to see them in their proper perspective; and (4) lead to a better understanding of how physical educators, at the present time, can best measure and evaluate postures.

Review of Objective Tests

Of the many tests that have been devised to measure and evaluate static anterior-posterior posture, only a few are available which have been sufficiently refined to approach the high standards of a suitable research tool.

Wellesley posture test. MacEwan and Howe, working in cooperation with the Department of Physical Education at Wellesley, devised an objective test to evaluate antero-posterior posture of college women from photographs. The test, one of the first to be classified as objective in nature, was published in 1932. (64:144)

The postural elements measured by the test were: (1) the relative position of the head and neck; (2) the degree of curvature or the depth of both the thoracic and lumbar regions of the spine; and (3) the distribution of weight at the base of support (referred to as segmental angulation and body tilt).

A special feature of the test was the use of aluminum pointers affixed at right angles to the following body landmarks: (1) the lower end of the sternum; (2) every other spinous process beginning with the seventh cervical; and (3) most prominent part of the uppermost segment of the sacrum.

It was believed that the exact location of the proximal attachment of the pointer could be determined by measuring the known length of the pointer from its distal or visible end. Such a technique was advantageous in that it increased the precision of measurement by allowing evaluators to designate the specific location of bony landmarks that were ordinarily concealed in a lateral view by muscular development and protuberances of such body parts as the scapula, the breast, and the elbow.

Other more observable body landmarks were also used in the analysis. These were: (1) apex of the angle formed by the chin and neck lines; (2) most prominent part of the abdomen; and (3) external malleolus.

Prior to taking the pictures, subjects were carefully prepared with pointers so that the aforementioned points of reference could be accurately located in the photographs.

Photographs were enlarged and prepared for measurement. As was mentioned previously, the exact locations of desired bony landmarks could be determined because of the use of aluminum pointers of known length. An exact tracing of the spinal curvature was made. In addition, other designated lines were drawn to facilitate accurate measurement. A "back line" was drawn to connect the seventh cervical and the most prominent part of the sacrum. A "front line" connected the apex of the angle formed by the neck and chin lines and the most prominent part of the abdomen. A third line was drawn horizontally at the base of support from the mid-point between extensions of the "front" and "back" lines to the external malleolus.

Analysis of the photographs proceeded as follows. The position of the head and neck was the measured distance from the anterior line to the apex of the angle formed by the neck and chin lines. The depth of the dorsal curve was the horizontal distance from the "back" line to the point of greatest convexity of the dorsal area, while the depth of the lumbar curve was the measured distance from the back line to the point of greatest concavity of the lumbar spine. The greater the distance or score, the larger the curve. A measure of the horizontal distance from the point halfway between the "front" and "back" lines to the fibular malleolus gave a score relative to the amount of body tilt and segmental angulation.

The gross posture score could be calculated mathematically by substituting the numerical results of measurement into the regression equation that follows:

$$X_o - 1.022X_1 + .128X_2 - .241X_3$$

o = Criterion.

1 = Sum of depths of dorsal and lumbar curves.

2 = Segmental angulation and body tilt.

3 = Position of head and neck. (64:152)

The developers of the test introduced an additional method to simplify the process of measuring and obtaining a gross posture score. This method, found to be equal in quality to the method involving the regression equation, consisted of three transparent scales which could be placed directly over the prepared photograph. This device made it possible to read the three desired measurements quickly and directly on the scales.

Glassow noted that each scale was marked with vertical lines "in units corresponding to the proportions shown in the regression equation." (16:237) This author further explained that the device permitted the examiner to score the picture ". . . without multiplying by the weighting of the regression equation. The multiplying has really been done by the markings on the glass." (16:237)

In essence, the algebraic sum of the three measurements became the gross posture score. The score could then be evaluated as to quality, converted to a total posture grade, by comparison to a predetermined norm--a range of numerical values with equivalent letter grades that extend from 1 or A to 25 or E-. The scale was reported as follows:

1 = A+	16 = D+
2 to 4 = A	17 to 19 = D
5 = A-	20 = D-
6 = B+	21 = E+
7 to 9 = B	22 to 24 = E
10 = B-	25 = E-
11 = C+	
12 to 14 = C	(64:147)
15 = C-	

Test reliability was not revealed in the original publication of the test but was later reported by Glassow. (16) Said Glassow,

> Studies at the University of Wisconsin show that for students who have had instruction in posture, the coefficient of reliability for 82 cases (college

> women) is .87. The reliability is lower than when students have had no instruction (.78)." (16:236)

MacEwan's claim for objectivity was based on the assumption that "The methods developed in the work . . . admit of no bias. . . ." (64:155) The validity of the test was established by comparing a series of measurements taken from 834 photographs with the composite scores of six judges evaluating the same photographs by their own standards. All judges were considered experts in the area of posture for women. The multiple correlation between a total of the three measurements and the established criterion of the experts was .812.

Massey posture test. Massey developed an objective test for evaluating antero-posterior posture that also involved photography, the location of body landmarks through use of pointers and adhesive marks, and angle measurements thought to be indicative of segmental angulation of major body segments. (65:3) The test was published in 1943.

Massey first established a criterion of good posture by utilizing the composite ratings of three judges considered to be experts in the area of posture measurement and evaluation. The established criterion--nine standard postures based on an evaluation of 100 silhouettes-- was then used to evaluate a number of angles and indices on 200 silhouettes of male subjects in an effort to select those angles which the investigator felt would best measure general and segmental poise.

The test in its final form consisted of four angles. These selected angles defined the angular relationships of the following major segments: (1) the head and neck with the trunk; (2) the trunk with the hips; (3) the hips with the thigh; and (4) the thigh with the leg. Detailed instructions as to how these angles were formed were reported by Massey. Angles were formed by drawing lines to connect designated points of reference that had either been marked on subjects prior to the photography or were easily located on silhouettes by perforations.

The established angles were measured directly on the silhouettes by use of a protractor and were recorded in terms of degrees of deviations from a straight line. The Massey Posture Score was determined by adding the differences obtained for the four angle measurements. The score was further interpreted by comparing it to a predetermined scale with equivalent letter grades. This scale was reported as follows:

8 - 22 = A	52 - 65 = D
23 - 36 = B	66 - 78 = E
37 - 51 = C	79 - 93 = F.

(65:17)

The validity of the Massey Posture Test was claimed on the basis that the sums of the angles obtained as a result of the analysis of the 200 silhouettes were in high agreement with the original criterion established by the three expert judges. The multiple correlation of the combined angles with the criterion was .985. The precision of the test, determined by establishing correlations of reliability and objectivity, was not reported.

Springfield posture test. Cureton and associates devised a test to measure the antero-posterior posture of men at Springfield College. (49; 47; 46) This test represents some of the most extensive work in the area of posture measurement and evaluation. (9:157) The Springfield Posture Test, published in 1941, was the result of scientific efforts which began in the early 1930's.

Cureton felt that a posture scale could only be developed after a method of measurement could be established as

> . . . being accurate (i.e., reproducing the measurement in its true size) and also reliable (i.e., giving a high degree of similarity between successive trials on the same object). . . . (49: 104)

The purpose of Cureton's first study (1931) was not, therefore, to construct a posture scale, but to conduct a " . . .

quantitative study of the validity of the instruments and methods of obtaining objective measurements in order to determine, first of all, the reliability of the methods of obtaining data." (49:104)

The spinal curves of live subjects as well as those of a manikin were measured using nine variations of three basic instruments--these being the conformateur, the spinograph, and the silhouettograph.

The study revealed: (1) that the spinograph and conformateur gave similar results; (2) that the profile silhouette was misleading and therefore of no value in quantitative research if used by itself; and (3) that the newly improved Cureton-Gunby Conformateur was the most accurate and most reliable of all methods tested.

Cureton concluded that the best measures of spinal curves could be obtained by using a combination of the silhouette and Cureton-Gunby conformateur. This scheme, according to Cureton, made it possible to obtain measurements of spinal deviations with an experimental error as small as one per cent.

The conformateur and the procedures for its use in posture testing might be described briefly as follows: The conformateur consists of a series of metal rods which project horizontally through a vertical upright. The rods, aligned vertically, are of standard length, and the position of each can be changed and locked into place as desired. To obtain an outline of the spine, the prepared subject is placed with his back to the projecting rods and with his feet in a designated position. Each rod, except the two designating the seventh cervical and the first sacrum, is tapped until it contacts a spinous process. After all rods are positioned and locked into place, a profile silhouette is taken to facilitate in the analysis. (23:24; 9:158; 49: 111, 112)

Subsequent studies were published in 1935 and again in 1941 in which investigators confirmed the precision of Cureton's proposed method of measurement, a combination of the silhouette and the Cureton-Gunby conformateur, for studying a number of postural elements. (47:81; 46:348)

Postural elements measured by the test were: (1) head posture; (2) shoulder droop; (3) Kellogg's Chest Ratio; (4) shoulder thrust; (5) abdominal ptosis; (6) hip thrust; (7) knee thrust; (8) kyphosis; and (9) lordosis.

The procedures for measurement consisted of: (1) preparing the enlarged silhouette with points of reference and line drawings to form desired angles, and (2) scaling the angles to determine the nature of the postural elements thought to be represented by the angles.

The points located on each silhouette were: (1) 7th cervical spinous process; (2) tragus of ear; (3) front surface of head of humerous; (4) point on spine opposite xyphoid process; (5) point marking top of glutei; (6) xyphoid process; (7) midpoint of line connecting (_9_) and (_5_); (8) center of great trochanter; (9) on pubis upper border; and (10) internal malleolus. (46:359)

Lines drawn on the silhouette to form measurable angles as well as linear measures were illustrated and described, in part, in the 1935 study. (47:91) A silhouette of the angles completely scaled as well as a detailed description of the angles as scaled appeared in the 1941 publication. (46)

Test validity was not determined. Larson noted that the postural elements measured by the Springfield test were "selected and scaled arbitrarily." (20:149) He further commented that "Validity is assumed; that is, deviations from the normal standard are not desirable, either physiologically, mechanically, and/or aesthetically." (20:149)

The test proved to be reliable and objective. The National Research Council reported coefficients for these two test criteria as follows:

(1) Head and neck	(.71)	
(2) Chest and abdomen	(.88)	
(3) Shoulders	(.88)	
(4) Spine, kyphosis	(.60)	
(5) Spine, lordosis	(.62)	(1:113)

The results of the Springfield objective test were compared with a subjective test of many of the same postural elements which had, in past years, been administered by trained experts of Springfield. (47) When elements were considered collectively, results showed the objective scheme to be two to five times as good as the subjective scheme for reliability, and three to fifteen times as objective depending upon the element evaluated. (47:91)

Yale posture test (original). Wickens and Kiphuth published an objective test of antero-posterior posture for men at Yale in 1937. (74:38) The investigators used photography, Wellesley's technique of utilizing aluminum pointers, and certain angle measurements developed by Cureton and associates in the Springfield method.

Measurements of the spinal contour were made possible by attaching aluminum pointers to the subject at the following points of reference: (1) the seventh cervical; (2) the point of greatest convexity of the dorsal region; (3) the point of inflection between the dorsal and lumbar spine; (4) the point of greatest concavity in the lumbar spine; and (5) the most prominent part of the sacrum. A sixth pointer was affixed to the lower part of the sternum to determine the position of the chest. Where bony landmarks could easily be observed from a lateral view, flesh marks were utilized. The tragus of the ear, the front tip of the shoulder, the center of the greater trochanter, the head of the fibula, and the center of the external malleolus were located by this method.

Prepared subjects were photographed from the left side. A plumbline, adjusted to fall through the center of the lateral malleolus, was incorporated into the photograph. This line was used as a vertical line of reference to facilitate in drawing horizontal lines, in evaluating segmental angulation, and in judging antero-posterior lean.

Photographs were enlarged to a standard size and then prepared for detailed analysis. The mimeoscope, an opaque glass with direct lighting from beneath, was used to prepare the pictures and to facilitate with measurements. The glossy surface of the photograph was placed down. Illumination from below caused the photograph to appear semi-transparent and, thus, permitted the examiner to locate body landmarks on the reverse side of the pictures. These points of reference were then utilized as a basis for formulating a number of specific angles which the investigators felt would represent selected postural defects. Angles were then measured and results were judged to ascertain the presence and degree of body lean, forward head, kyphosis, lordosis, over-carriage and abdominal protuberance. The relative position of the chest, shoulders, hips, and knees were also determined. Detailed descriptions of the exact method of formulating angles and measuring to determine results were reported by Wickens. However, the exact manner of grading postural elements by angle measurements was not revealed.

Although no standard or norm, based on the described angle measurements, was established for this particular test, the reliability, objectivity, and validity of the Yale method were determined. Reliability and objectivity of affixing pointers and scaling were established by photographing thirty subjects on two different occasions--the subjects being prepared on each trial by two different examiners. The combined reliability and objectivity coefficient ranged from .721 to .854. The objectivity coefficient was also established for grading pictures. Selected angles on two identical sets of

100 pictures were graded by two different investigators. The coefficients ranged from .956 to .966. Enlarging photographs four times the original size (5 x 7) was also analyzed for the effect on precision. The coefficients ranged from .945 to .979.

The validity of the Yale method was determined by evaluating specific angle measurements (head and neck, kyphosis, and lordosis) using the Yale Posture Test as well as the Springfield Posture Test. The multiple correlations yielded validity coefficients ranging from .619 to .90, depending upon the element evaluated.

Yale posture test (revised). In 1952, Blesh, Meyers, and Kiphuth adapted the previously described Yale Posture Test devised by Wickens. (28:106; 75:4; 41:20; 26:279) The test revision was made possible by the installment of newly developed PhotoMetric equipment at Yale.

The PhotoMetric technique of photographing provided the investigators a detailed record for analyzing the total standing posture of college men. Four images, views from above the head, from the front and back, as well as from the left lateral, could be obtained simultaneously on one exposure. The process was made possible by photographing a panel of mirrors which picked up the four proportionate images of the subject reflected from a series of mirrors placed at specific angles. Either a photograph or a lantern slide could be reproduced from the negative to provide a permanent personal record. The technique also provided equipment for projecting the slides to one-half life size, approximately five times the size of the photographs previously used for evaluation.

Prior to the test, subjects were prepared by locating desired points of reference with flesh marks. As in the earlier test, aluminum pointers were applied to certain points of reference that would be concealed from view by various body parts. Since the additional three views made it possible for investigators to analyze aspects of standing posture not possible in the traditional photograph of anterior-posterior posture, the points of reference varied slightly from those utilized in the original test.

Measurement and analysis proceeded as follows: (1) reference points were located on the projected image; (2) lines were drawn to formulate a series of pre-established angles thought to be representative of postural elements which the investigators desired to measure; and (3) angles were scaled by means of a special protractor ruler.

Many of the postural elements which had been evaluated by the previous test were incorporated into the new test. These were angle measurements which described the head and neck position, kyphosis, lordosis, over-carriage, chest carriage, and hip thrust. Because the technique allowed the possibility of accurate angle and linear measurements of any part of the body, additional measurements were also introduced to re-evaluate a few of the original postural elements as well as to study several new elements. These new measurements provided additional data to evaluate over-carriage as well as a linear measurement to re-evaluate the position of the head and neck. Angle measurements were also obtained which assisted in the analysis of the pelvic tilt and shoulder displacement.

Investigators are still in the process of perfecting the test. As yet, no material has been published that explains the exact method of evaluating and grading the postural components on the basis of test results. Neither has a report been made regarding the evaluation of test items for scientific authenticity (validity) and precision (reliability and objectivity). Likewise, investigators are still in the process of collecting data for the purpose of establishing test norms for each element. Regardless, it is thought that the Yale Posture Test, as revised, is " . . . the most objective posture appraisal available." (26:284)

Cureton-Wickens center of gravity test. In tests described thus far, the approach to evaluation has been based on the premise that the quality of posture can best be determined by studying the relationship of the major segments.

A second school of thought has also become an approach to evaluation. Many have believed that a definite relationship exists between the center of gravity, the line of gravity, and the quality of upright posture. Innumerable references have appeared in the literature which have implied the importance of using the line of gravity and its relationship to certain body landmarks when evaluating antero-posterior posture.

In 1935, Cureton and Wickens, noting that the concept of the center of gravity and the line of gravity as related to posture had not been subjected to scientific scrutiny, conducted a study which utilized the center of gravity test as a diagnostic test of antero-posterior posture. (48:93) This study was the first in a series of attempts to evaluate quantitatively the significance of the gravity line to posture.

An adaptation of the technique devised by Reynolds and Lovett was used for determining the exact location of the center of gravity line forward to the internal malleoli. The apparatus, as constructed, consisted of a board of known length and two lever-arm type scales. The board, marked in the exact center by a vertical indicator, was placed so that each end rested on the center of a weight scale.

The procedure for administering the test was as follows: The subject took a position on the balance board facing the "forward" scale. The examiner then aligned the subject so that the internal malleoli were in line with the vertical projection marking the center of the balance board. While the subject assumed a natural stance, each scale was balanced--the forward scale being adjusted first. Readings for both scales were made and recorded.

The exact location of the line of gravity as related to the internal malleoli was determined immediately by referring to a table prepared for this purpose. The National Research Council described this table as follows:

> A scoring table is provided which is entered with the pounds of weight on the front and rear scales (each minus one-half the weight of the board) and the location of the vertical gravity line in front of the internal malleoli is given. (1:114)

Also available was a percentile rating scale for determining the percentile score. Meyer gave a formula that could be used for calculating the forward distance of the line of gravity from the internal malleoli should the published tables not be available.

$$FSX = RS(BL-X)$$

where X = Distance of center of gravity from front scale.

FS = Reading of front scale minus 1/2 board weight.

RS = Reading of rear scale minus 1/2 board weight.

BL = Board length. (26:288)

He further noted that "Having found X, the distance of the gravity line from the internal malleoli (d) is 1/2 BL-X." (26:288)

To determine the validity of such a test, the researchers correlated test results with a number of additional measurements available for the subjects. Relationships were reported as follows:

r	center of gravity test and body lean	.86
r	center of gravity test and Rogers' Strength Index	.43
r	center of gravity test and Rogers' Physical Fitness Index	.64
r	center of gravity test and Vertical Jump	.42
r	center of gravity test and Kyphosis	-.44

(1:113)

Cureton and Wickens analyzed the data as follows: (1) that the center of gravity test was an excellent measure of the degree of body lean; (2) that the upper trunk was noticeably straighter in those who had forward body lean; (3) that the distinct forward lean was the habitual stance of those found to be in better physical condition as measured by the Rogers' Strength Index; and (4) a distinct forward lean was the habitual stance of those found to be better athletes, as measured by the Sargent Jump.

The investigators concluded that: (1) men who were in good physical condition muscularly and who had better aptitude for athletics had flatter upper backs; (2) that a definite relationship existed between posture, physical fitness, and athletic ability; and (3) that the Cureton-Wickens technique for establishing the line of gravity as it related to the base of support was a satisfactory test for diagnosing the quality of posture.

Although no report was given as to the objectivity of the method, the reliability coefficient was reported to be .90 to .93 for four different groups of subjects.

Analysis of Methods of Measurement

Why are researchers today still seeking answers to questions that were asked in the early beginnings of posture measurement? That investigators today are still seeking solutions to research problems that existed from the beginning is a likely explanation. Indeed, posture measurement has been plagued with innumerable problems.

<u>Validity</u>. It appears that the most severely limiting problem in posture measurement has been the inability to establish validity--the insufficient evidence that tests of posture are scientifically authentic.

Test validity was previously discussed in terms of its importance--that, unless a test was an incontestable measure of its proposed purpose, test results would not only be misleading, but useless.

Of the objective posture tests reviewed in this study, only three were investigated to determine validity coefficients. MacEwan and Howe reported an "r" of .812 for the Wellesley Posture Test. (64:152) Massey obtained a multiple correlation of .985 between the established criterion and his posture test. (65:21) Validity coefficients ranged from .619 to .90 for three selected elements of the Yale Posture Test (original). (74:46)

These validity coefficients, when evaluated by the standard numerical scale devised by Mathews, rated as follows: Wellesley Posture Test--Very good; Massey Posture Test--

Superior; Yale Posture Test--Very good. According to the standard scale, these validity ratings, except for a relatively low coefficient determined for one postural element on the Yale test, are quite acceptable for tests of posture.

Several investigators have emphasized that, regardless of the size of the correlation coefficient, the degree of validity cannot be determined by statistical analysis alone. (30:112; 16:40; 9:30) Because the coefficient of correlation is only an expression of the degree to which the proposed test measures the same qualities as does the criterion, some have come to view the coefficient of correlation as an "indicant of validity." (26:61) Clarke and Glassow emphasized that evaluation of test validation is not just a matter of judging the acceptability of the established "r" but must also involve an evaluation of the quality of the criterion with which the test scores have been correlated. (9:30; 16:40) In other words, the investigator must also evaluate the validity of the criterion in an effort to establish "the degree to which the criterion measure represents the quality being measured." (9:30) McCloy noted that in the final analysis, the validity of the test can never be higher than the validity of the selected criterion measure.

(24:35) McCloy further emphasized that "The criterion, in order to be acceptable, must be valid regardless of how complicated it turns out to be." (24:29)

Researchers have used a number of types of criteria in validating tests. Glassow noted that the criterion which lends itself to statistical correlation is the only method that could be used to determine the degree of validity, but that other techniques have been used readily to determine evidence of validity. (16:40) Several authors were surveyed in an effort to obtain a complete listing of the types of criteria that have been used as well as the views of experts to give indications as to the quality of each. (9:20; 16:30) Those criteria which, by nature, could be subjected to statistical analysis and, thus, denote the degree of validity were: (1) subjective judgment; (2) established tests; and (3) composite scores. Other techniques utilized to give further evidence of validity were: (1) critical analysis of the ability in terms of its fundamental elements; (2) comparison of the successfulness of groups known to differ in the ability to be measured; and (3) analysis of functional ability. Where posture tests have been validated, only three of these above types of criteria have been utilized--these being: (1) subjective judgment; (2) established tests; and (3) analysis of functional ability.

Only a few tests of posture have been validated by means of the coefficient of correlation. Massey noted that the criterion most frequently adhered to when validating these tests was the subjective ratings of authorities in the area of posture and body mechanics. (65:8) Where used, several experts were asked to evaluate subjectively the static anterior-posterior posture of a specified number of subjects. The combined judgment of the authorities was considered a suitable criterion if a high intercorrelation among the judges could be obtained. This technique was used by Massey (65), and MacEwan (64).

Glassow emphasized the importance of selecting highly competent judges in the field of posture. This authority noted that ". . . the coefficient of correlation will be valid only to the degree that the judge is capable." (16:40)

Such a statement seems so obvious as to preclude argument. But, as discussed previously, the capability of selected judges is evidently not sufficient to assure that accurate measures can be obtained. For example, Cureton found that a subjective test of posture gave results of only 13.4 per cent better than pure chance guesses as an average in ranking pupils; that the objective scheme, on the other hand, was four times as good, or 45 per cent better than chance. (47:92) The two tests supposedly measured the same postural elements and had been administered by trained experts who had worked closely together for several years.

The use of subjective judgment in formulating a criterion for the purpose of validating a test is known to have limitations which render it inadequate as a technique for research purposes. Regardless, Glassow noted that wide usage of this type of criterion has been necessary because of the unavailability of better types. (16:33) Larson pointed out that validity could also be established if results of the test in question correlated high with the results of a previously validated test chosen as the criterion test. (20:259) Only one test of posture has been validated using an established test as the criterion. Wickens attempted to establish the validity of selected aspects of the original Yale Posture Test by measuring selected angles and correlating results obtained by the Yale method with results obtained on the Springfield Posture Test--the test selected as the criterion. (74)

It is apparent to this writer that the correlation between the Yale test and the Springfield test--a range from .619 to .90--does not present a true picture. No attempt was made by Cureton to establish the validity of the

Springfield Posture Test, the test used as the criterion. It would seem that the resulting correlation was only an indication of the degree to which each test measured the same things; that the investigators were not justified in assuming that the resulting correlation indicated that either of the tests was a valid measure of the postural components studied.

Cureton reported "validity" of the Cureton-Gunby Conformateur after making a series of comparisons on a manikin. It was stated, "Comparison with actual measurements of the manikin showed 99 per cent accuracy in full size." (1: 107) Clarke used Cureton's validation procedure as an example of an application of the type of criterion known as "functional evidence." (9) This criterion supposedly reveals, under normal circumstances, "functional evidence of the element for which the test is constructed." (9:32) It appears to this writer that because the human body does not function in the manner of a manikin, because the human body is multisegmented and quite capable of mobility, the use of a manikin as a criterion of "functional evidence" of human posture was not justifiable.

Thus far, discussion regarding the quality of validity has related to: (1) a comparison of available validity correlations to standardized numerical scales designed to help evaluate the degree of validity; and (2) an analysis of the quality of the criterion utilized in validating the test. It would appear that these two methods of judging the quality of validity might not necessarily be sufficient; any interpretation which researchers might make regarding test results could also influence reported test validity, and could be misleading.

Glassow pointed out that many tests in physical education ". . . claim to measure nothing beyond the ability used in the test." (16:30) For example, MacEwan stressed that no attempt was made when developing the Wellesley test ". . . to extend the validation of posture grades to include definitions of good and poor posture and their relation to longevity, motor ability, viscereal mechanics and physiological function." (64:155)

It appears that misinterpretation could possibly result and therefore affect validity if the investigator chooses to make assumptions beyond the known capacity of the test. The nature of this type of misrepresentation of test validity might be clarified through illustrations related to posture and posture research. For example,

(1) a test may be a valid measure of a person's ability to stand; but validity could be

questioned if the author makes the assumption that those who score well on a static posture test will also assume an excellent carriage in daily activity.

(2) a test may be a valid measure of the "quality of a manikin's upright stance;" but validity could be questioned if, on the basis of this knowledge, the assumption is made that the test is also a valid measure of the quality of the human stance.

(3) a test may be a valid measure of posture for a particular age and sex; but validity can be questioned if researchers use such a test in a study that involves another age group and sex.

(4) a test may be a valid measure of the center of weight of subjects, a valid measure of the relationship of the line of gravity to the base of support; but validity may be questioned if the author makes further claims that the test is also a valid tool for a diagnostic test of anterior-posterior posture.

For each of the above examples, specific instances could be cited where investigators have violated the concept of validity in the manner described. Cureton's claim that the center of gravity test is also a diagnostic test of posture appears to be a classic example. (48:93)

Cureton attempted to establish a test for determining the line of gravity as it related to the base of support as a diagnostic test of posture. It was reported previously that test significance was determined by correlating scores for the line of gravity with scores obtained on the following:

(1) Body lean; (2) Kyphosis; (3) Rogers' S.I.; (4) Rogers' P.F.I.; and (5) the Sargent (vertical) jump. (48:99)

Cureton's interpretation of results led to the following conclusions: (1) that a positive relationship existed between the gravity line and posture and between posture, physical fitness, and athletic ability; (2) that the line of gravity test is a satisfactory tool for diagnosing the quality of posture. (48:105)

Other investigators have conducted similar studies but have found no significant relationship between posture and the line of gravity as determined at the base of support. For example, Flint recently studied the line of gravity as related to the base of support in an attempt to establish its significance as a diagnostic test of posture. (51:141) A modification of the Reynolds-Lovett technique was used to determine the location of the gravity line at the base of support. Evaluation of total antero-posterior posture was accomplished through use of the Massey test. The coefficient of correlation between results of the gravity line test and the total posture score was an insignificant relationship of .032. Flint stressed that

> Although the concept of the center of gravity and the gravity line appears basic to an evaluation of both static and dynamic posture, the position of

> the gravity line, used as a single, objective score, is not a satisfactory or meaningful measure of standing posture. (51:144)

Separate studies for the same purpose had previously been conducted by Johnson and Crowley at Wellesley College. Neither of these investigators found a significant relationship between the quality of posture (as measured by the Wellesley test) and the determinations of the line of gravity test at the base of support. (71:92, 93)

Several researchers have discussed the fallaciousness of using the gravity line as a test for evaluating segmental alignment. (51; 65; 7; 34; 26)

Hellebrandt (59) found that although the center of gravity shifted constantly above the base of support, the oscillations were always confined to a limited area; and that in every subject studied, the average location of the center of gravity to the base of support was always close to the geometric center of the supporting base. (59:471) Wells concurred (34:347) This investigator found that regardless of the position assumed in the upper body, the gravity line remained close to the center of the base of support. (34:351)

Massey noted

> . . . that poor alignment of body segments might exist without noticeable displacement of the center of weight as measured at the feet. . . . that moments

> of force set up by some segments being out of vertical alignment might be equalized by compensating in other segments thus tending to leave the center of gravity weight at the feet relatively undisturbed. (65:7)

Flint agreed with Massey. This researcher criticized the use of both the gravity line test and the body lean test because she believed these failed to take into consideration the remarkable capacity of the body to make compensatory adjustments in an effort to maintain segmental balance. (51:144) Flint explained that,

> Because of the effective compensatory adjustment made by the body to maintain balanced alignment, the weight center of the body will remain approximately centered over the supporting structures regardless of the extent of deviation from the midline of the individual body segments. (51:143)

Flint justified her beliefs with an example encountered in her study:

> . . . a marked backward lean of the upper trunk (overhang) was equalized by an anterior shifting of the pelvis and thighs; a segmental deviation with no change in gravital line placement. (51:144)

Flint also found that a faulty pelvic tilt and lumbar lordosis caused no noticeable change in the placement of the gravity line. (50:20)

In regard to the high correlation between the line of gravity and body lean, Wells had this to say:

> This denotes a high degree of positive relationship, but on the other hand, body lean is the position of the body which is associated with the

> antero-posterior shifting of the line of gravity. They are one and the same thing. In fact, one wonders why the relationship was only .864 instead of 1.0. (34:350)

The findings regarding the habitual forward lean of men who were in better condition and better athletes appears justifiable, if one can say that the Rogers' Strength Index and Physical Fitness Index are satisfactory tests, by themselves, for fitness and athletic ability. However, it would appear that these researchers, through interpretation, stretched the limits of test validity when they concluded that men in better condition who were better athletes had better posture because the habitually forward lean correlated negatively high with kyphosis, indicating that a large number had flat upper backs.

It is the opinion of this writer that a high negative correlation between forward lean and kyphosis should have been expected; that in the case of a forward placement of the weight, as in forward lean, the subject would automatically compensate by flattening the upper back in an effort to maintain a segmental balance with the center of gravity remaining over the base of support.

There would also seem to be room to question why these writers felt that this test of body lean could ever be used as a diagnostic test of posture. Body lean is, perhaps, an important item to measure in evaluating posture, but it is only one of many factors that must be considered before a posture analysis is complete. The National Research Council considered this test satisfactory for demonstrating ". . . how a subject bears his weight on his feet by location of the vertical gravity line as it passes through the feet." (1:113) It appears from the discussion relating to Cureton's claim, that the test is a measure of more than this, and exemplifies the danger that can accrue from assumptions.

Criteria for validating tests of posture are standards of performance which the test in question must agree with. It appears that the criteria available for validating posture tests have been far from adequate and that tests, themselves, have come to reflect this inadequacy. In other words, it appears that the value of a test is relative to the value of the criterion. If the standard is not a true measure of validity, then no stringent demands would be made upon the test on trial to produce evidence of authenticity. Several examples which appear to support this thinking follow.

It was reported that the Wellesley test had a validity rating of .812. (64) Yet, Fox believed that this test of posture was invalid as a measure of spinal contour. (30:317)

This authority noted that evidence is available which indicates that the depth of the spinal curvature is affected by variations in inherited structure as well as variations in body build. Fox criticized the Wellesley technique because she believed the ". . . method fails to take into consideration real anatomical differences in the shape of the vertebrae which, in turn, affect spinal curvature." (30: 317) It would seem that these same views might be extended to those measures of the Springfield test that also involved determinations of spinal depth.

Should such a criticism ever be justified, it would serve to illustrate the severe limitations of subjective judgment as a criterion for validating posture tests and the fallaciousness of using external measures to judge an internal bony framework. It would seem, further, to illustrate invalidity in that the depth test would not give fair rankings to spinal curvatures that should, in reality, be classified as variations of normal instead of deviations from normal; that the test would not take into consideration individual differences due to heredity structure and body build.

Flint conducted a study in which she revealed the fallacy of judging the contour of underlying bony framework by external methods of examination. (50:15) Her study exposed the lack of validity for an angle measurement of lumbar posture utilized by both Wickens and Cureton. (74; 47)

Flint measured the lumbar curvature of subjects using photography and an external angle measurement for lordosis--an angle measure which was used in both the Yale test and the Springfield test. This angle was formed by drawing lines from the point of greatest inflection between the dorsal and lumbar curves to the point of greatest concavity in the lumbar region and from the latter point of reference through a pointer affixed to the most prominent part of the sacrum.

The lumbar posture of the subjects was also evaluated using X-ray. The angle formed on the X-ray followed the lines of the angle formed on the photograph but traced exactly the bony structure which outlined the lumbar curve and sacral tilt.

Thirty subjects were tested. The multiple correlation between the angle measure obtained by photograph and by x-ray was insignificant. Flint found that measures of the external body which appeared in the photograph in no way compared to the underlying bony framework as revealed through x-ray.

This researcher concluded that ". . . studies of external form of the body . . . give only small consideration to underlying bony framework and body build." (50:15)

Such a study illustrates why x-ray has been considered the most accurate means of obtaining a record of the subject and why Massey described this technique as a "thoroughly scientific approach to the problem." (65:5) The study likewise exposed the possibility that all external body measures of this type, made possible by skin markers and photography, might be completely invalid as measures of the true segmental angulation. The importance of validating external measures of postural components by x-ray is also demonstrated.

That test validity might be relative to a definite situation can also be demonstrated. The validity coefficient for the Massey test was extremely high--.985. Massey's attempt to correlate measurements obtained by several posture tests with the above-mentioned criterion is revealing. Results showed coefficients of correlations between his criterion and scores of the selected tests to be as follows: (1) Massey criterion and Goldthwait test, .71; (2) Massey criterion and MacEwan test, .560; and (3) Massey criterion and Kellogg test, .825. (65:19) It might also be noted that other investigators have correlated test scores obtained with the Massey test with other criterion measures obtained by combined ratings of judges and have not been able to obtain the high validity coefficient reported by Massey. (30:316)

The foregoing discussion seems to substantiate Meyer's statement regarding validity; i.e., that what may be a valid test for measuring an ability of one group may not be valid for another. (26:60) It might further indicate that one test of posture does not necessarily measure the same thing as another very similar test of posture. On the other hand, it might mean that different groups of judges will differ considerably in their subjective estimate of posture and, therefore, that resulting criteria will differ considerably.

It is the opinion of this writer that the crux of the problems of posture research is test validity. It appears that if a test is a valid measure of the ability under consideration (posture) and that if each measure of the test is a true measure of the respective postural element (component), the test becomes a means to the desired end. However, if the test, in whole or in part, is not a true measure of the ability or component under consideration, the test becomes an end in itself.

A researcher measures to find fact and evaluates to establish the value of the fact. But if the means of measurement and evaluation is false, then how can one know the true nature of the end, the true nature of the facts and the value that can rightfully be attributed to these facts?

Precision. A second major problem confronting researchers in the area of posture appears to be the lack of precision in instrumentation.

The dependability of the available tests of anterior-posterior posture has been a subject of concern to physical educators for many years. Cureton pointed out that many of the existing posture tests have never been tested for reliability. Furthermore, he revealed that where reliability had been determined the results have ". . . mostly been far below the accepted research standard of .80." (47:82) Stated Cureton,

> There have . . . been many attempts to produce a satisfactory quantitative procedure. No satisfactory method has as yet been produced which is accepted as being sufficiently accurate for research upon the many postural problems staring us in the face for reliable answers. (49:102)

Although the above statement was made in 1931, the truth of the message appears to remain today.

A major limitation facing the researcher who has chosen to study various aspects of posture through measurement and evaluation is the number of variables that may never be controlled sufficiently to reduce significantly the fluctuations in scores that occur, even in carefully administered test-retest situations. Larson chose to call these variables "chance errors." (20:434) Scott referred to them as "extraneous factors." (32:243)

Larson noted that these "chance errors" are capable of increasing or decreasing the size of a score as well as operating in both directions. He further stressed the importance of knowing and considering these if reliability is to be improved. (20:434)

It appears that the influential variables affecting precision of posture tests have been active in six areas: (1) the test; (2) the ability to be measured (posture); (3) the subject being evaluated; (4) test administration; (5) the procedures of measurement; and (6) evaluation of results.

It was recognized that a comprehensive discussion of the problems encountered in each of these areas would be far from adequate due to the fact that each test, each subject, each administrator, each administration would yield its own variables. In other words, it was felt that the nature and effect of variables would be relative to each testing situation. For this reason the discussion has been limited to selected variables that appear difficult, perhaps impossible, to control.

Precision appears to be affected adversely by a number of limitations inherent in objective posture tests. For example, Cureton revealed several inadequacies in the photographic methods utilized in securing permanent pictoral records. (49)

The profile error, that the silhouette did not represent true spinal measurement due to muscular and bony contours, was the major criticism of the silhouette. Problems in measurement, because of a lack of clearly visible features, as well as the smallness of the photograph, were also discussed. (49:108, 110) The limitations recognized in the profile silhouette caused Cureton to conclude that the silhouette alone was of no value in quantitative research and that additional methods would have to be used with the silhouette to produce a more graphic record suitable for quantitative analysis. (49:108) Cureton also discussed technical photographic errors due to equipment. (49:110)

Pictorial records have been made graphic and therefore suitable for quantitative analysis by using such methods and devices as flesh marks, aluminum pointers, and the conformateur. Fleshmarks have been used where the designated point of reference could be easily viewed from the side. The aluminum pointers and conformateur rods have been advantageous in locating landmarks ordinarily concealed in a side view by muscular contour, extremities, or bony protuberances.

The utilization of skin markers might best be described, however, as "necessary evils;" for a major but unavoidable variable in posture testing has been the dependence upon external skin markers to designate internal bony landmarks for the purpose of obtaining angular and linear measurements.

Wells had long recognized the inaccuracies involved in locating bony landmarks by palpation. This investigator had conducted a study at Wellesley to determine the relationship of the line of gravity to designated landmarks from the base of support upward. The subjectivity involved in locating landmarks was given as one of the reasons for the variable results obtained in the study. (34:358)

Scott and Brunnstrom also discussed the problem. Scott noted that the landmark at the hip joint was especially difficult to find and could be located accurately only if x-ray was used. (32:316) Brunnstrom described several techniques to assist an examiner in determining bony landmarks with more accuracy. (8) The inaccuracy resulting from moving soft tissue when locating a deep skeletal landmark by use of skin markers was also discussed. (32:316)

This writer conducted a pilot study at the University of North Carolina at Greensboro in preparation for an experimental study involving the analysis of anterior-posterior posture for college women. Even though Brunnstrom's suggestions were utilized, this investigator experienced the difficulties encountered when locating body landmarks by observation and palpation. The point of reference at the hip joint was especially difficult to find. This writer became keenly aware that each selected location of each landmark was, in the final analysis, the result of a poorly educated guess.

Fleshmarks and aluminum pointers (of the type used by Wellesley) were used to mark points of reference needed in the analysis. This investigator experienced the fact that movement of soft tissue over bony protuberances caused innacurate placement unless extreme cautions were taken. In addition, it was recognized that the slightest change in any body part resulted in a repositioning of previously applied skin markers--a problem which indicated the importance of requiring the subjects to assume, as best as possible, the same posture that would be required in the process of photographing.

Limitations of the use of aluminum pointers were also discovered. This investigator experienced difficulty in assuring that aluminum pointers marked the point of reference on the body at exact right angles to the vertical and in the frontal plane and that pointers, easily bent or moved, remained in the desired position as described throughout the testing. The importance of such care in placement of pointers was recognized from the beginning. Regardless, inaccuracies encountered when using the pointer were clearly demonstrated when enlarged photographs and projected slides were analyzed. The slightest variation in pointer position affected many of the measurements. It became necessary to estimate subjectively the location of the proximal end of pointers. Such a procedure led one to doubt the reliability of this device and to doubt the exact location of designated landmarks.

Glassow was of the opinion that unreliability in posture testing was due not so much to inadequacies of the tests themselves but to the variations encountered in the ability to be measured. (16)

Glassow and Clarke recognized that the human body, being multisegmented and quite capable of mobility, could not be expected to assume the exact same position on each testing situation. (16:18; 9:165) Glassow emphasized, "Variations rather than exact duplications are to be expected on repeated measures of human abilities." (16:18) Glassow further stressed that, when human abilities were being measured, the variations in scores could not necessarily be attributed to inaccurate instruments; that "The variation lies in the human being, not in the instrument." (16:18) Under circumstances such as these, Glassow believed that a test could be accepted as reliable if test-retest scores were "in reasonable agreement." (16:17)

The complexity of the problem is magnified by the effects of body sway. Hellebrandt described static posture as ". . . movement upon a stationary base." (60:473) Experiments conducted by this researcher revealed that the body center of gravity shifted constantly above the base of support; that sway was an individual matter; but that oscillations were always confined to a relatively limited area; that in every subject studied, the average location of the center of gravity to the base of support was always close to the geometric center of the supporting base. Hellebrandt noted that sway followed a fairly uniform pattern--that of a figure-of-eight, with the greatest sway being in the anterior-posterior direction. (59:471; 56:21)

The effects of postural sway on the reliability of posture testing utilizing the gravity line was studied by Hellebrandt. She found that sway especially affected the reliability of testing when individuals were compared in series. (56; 57) Wells attributed the difficulty of locating body landmarks to the phenomenon of sway. (34:358) She suggested one possibility for making allowances for sway in studies involving the line of gravity. Wells reasoned that data from a series of tests might make it possible to establish a normal vertical zone of the line of gravity which could be used as an area of reference for the suggested landmarks.

Hellebrandt noted that the variability due to sway could be reduced to some extent by requiring the subject to focus vision on a selected point. Hellebrandt also found that the position of the feet affected body sway and that a stance with the toes turned out 30-40 degrees was the position of greatest stability. (59:471, 472)

A number of variables are obviously due to the nature of the subject being tested. The habitual posture of the individual is the position of most importance to examiners. Wells emphasized that a record of static posture is reliable only to the extent that it is representative of this habitual posture. (34:355)

Wells and Phelps expressed doubts that such a posture could be recorded under testing conditions. (34; 28) Stated Phelps,

> Habitual posture cannot be determined if the attention of the individual is attracted to his posture, as he will then consciously or unconsciously attempt to correct or change some phase of it. (28:60)

He further noted, however, that temporary adjustment made by the individual could be detected; that there would be "evidence of undue muscular tension or a strained position, rather than the easy relaxation . . ." (28:60)

This writer has entertained the possibility that the "learning" or "practice effect" might occur during or before testing and therefore affect reliability. In a personal correspondence to Mathews, the Chairman of the Department of Physical Education at Wellesley related the following: that students had come to recognize that the posture grade could be improved by bending the knees slightly to flatten out the lower back and by leaning well forward. (23:242)

Meyer and Mathews, aware of the importance of consistency in the nature or status of the elements being measured, emphasized that test reliability was based upon the assumption that these elements would not change during the interim or between the testing. (26:62; 23:20)

Larson and McCloy emphasized that, should subjects experience a learning or practice effect through testing, the test-retest would not present a true picture of test reliability. They pointed out that under such circumstances, the test user must rely upon the split-halves or parallel forms as a proof of reliability. (20:434; 24:34)

Other variables thought to affect the individual and his posture and, ultimately, test reliability, were noted by Phelps and Scott. (27:60; 32:234) These were: (1) time of day; (2) time of meals; (3) fatigue; (4) momentary attitude of subject; (5) equipment; (6) condition of surrounding area, such as heat, light and humidity; and (7) lack of specific directions for performing the test.

Norms. A third major weakness of posture measurement has been the unavailability of established norms. (9:165) It was previously noted that the only norm available was that could be improved by bending the knees slightly to flatten out the lower back and by leaning well forward. (23:242)

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Norms. A third major weakness of posture measurement has been the unavailability of established norms. (9:165) It was previously noted that the only norm available was that established for the Wellesley Posture Test. Hellebrandt believed that MacEwan's numerical scoring system did ". . . no more than replace individual judgment by group evaluation." (58:225) Clarke criticized this scale as an arbitrary one, ". . . established . . . for overall posture positions." (9:65)

Little has been written regarding the disadvantage of a test that allows the examiner to obtain only a composite or total posture score or grade. The criticism that is available, however, clearly points out the severe limitations of such a practice in posture research.

Clarke, Cureton and Glassow are among the few who have repeatedly expressed concern over the use of this method. (9; 47; 46; 16) The major objections of these writers to a general posture grade were:

(1) that the ". . . result is a total score made up of an average or sum of very immeasurable items which cannot be interpreted in such an over-simplified system." (46:356)

(2) that the inability to evaluate the component parts which make up posture prevents the examiner from knowing specific areas that should be recorded as weaknesses and postural defects. (9:154; 46:356)

(3) that the total approach to analysis prevents a detailed analysis of the resulting defects in terms of cause and effect; for example, would a case involving over-carriage be due

to an increased dorsal curve or to increased lumbar lordosis? (16:240)

(4) that such an analysis is useless for the examiner if he desires to use the test scores as a basis for prescribing postural exercises in accordance with individual needs. (9:154)

(5) that the total posture score, an average or sum, can be misleading in that an individual could possess postural deviations of a "third" degree and yet obtain a posture score of "B" or "good."

(6) that the "Opinions as reported in the A, B, C, D system are not very susceptible to accurate statistical analysis. The precision of this system is doubted." (47:82)

(7) that "The rough allotment of an 'A' in body mechanics means excellent in carriage of all segments. This cannot be determined with certainty until more is known about the correlation of mechanical alignment with organic functioning of each segment in question." (47:82)

Cureton made a plea for ". . . a series of precisely known, understood, and carefully measured separate elements." (47:82; 46:356) Clarke and Glassow stressed the importance of utilizing methods of scoring that would permit evaluation of separate postural elements. (9:154; 16:240) The importance of such a characteristic for a test used in posture research was summed up by Glassow when she stated,

> An accurate method of grading postural elements (rather than total posture) is essential to the study of postural age development and to the study of the effect of certain activities and specific exercises on postural change. (16:240)

The foregoing criticism offers explanation as to why recent researchers have shown no interest in norms for overall postural stance.

It appears that there is a definite need to develop quantitative norms for each measurable postural element or component. Research findings seem to substantiate the fact that each norm, if to be of value, should be characterized by a quantitative range of normalcy,

(1) with the extremes of each range being limits to what could be accepted as normal;

and

(2) constructed on a classification index involving age, sex, and body build.

General Analysis

When we consider the fact that progress in any field seems to run a parallel course with the development and perfection of instrumentation, an analysis of problems of posture measurement and evaluation seems to offer some explanation as to why research in the area of posture has been retarded.

A statement made by Gardner Murphy, and quoted by Davis and Logan appears appropriate.

> . . . where simple facts are difficult to come by and generalizations more difficult to document,

> the findings meet a massive resistance seldom encountered in the relatively simple structure offered by the physical sciences. (14:131)

Davis and Logan responded to this quotation with the following simple comment. "How hobbled we are without devices of measurement!" (14:131)

Clarke emphasized that although a posture test is known to be "somewhat inaccurate, the fact that it remains superior to any other available method is justifiable for its use. (9: 32) This writer feels that such an opinion regarding testing might be justifiable in the <u>general</u> physical education program <u>if</u> the physical educator could justify the time, effort and expense involved with objective posture testing. However, it would seem that Clarke's view cannot be justified within the realm of research. The "chaotic condition" of posture research is obviously due to the inability of our tests to meet up to high standards of good research tools.

It is the opinion of this writer that the revised posture test presently used at Yale University is the only objective test which exhibits characteristics that qualify it as a potential research tool.

The PhotoMetric Corporation, which originally developed the technique to facilitate more accurate research conducted by the tailoring industry, made the following statements regarding the possibilities of this equipment:

> For the first time a scientific method for obtaining and recording precise measurements of an object by photography is now available to industrial and research projects which require:
>
> 1. Accurate contour measurements of irregularly shaped objects.
>
> 2. Several correlatable views with direct mathematical relationships.
>
> 3. A compact, accurate and permanent record of form and measurement. (75:6)

Blesh, one of the Yale investigators responsible for adapting PhotoMetric Photography as a tool for posture research, discussed several advantages that this new method might provide for this area of research. For example, traditional methods of photographing allowed the investigator to make a record of only one view at a time--whereas the new technique provided four images simultaneously from a single exposure. (75:6) Blesh stated that such a process " . . . greatly increased the extent to which evaluation of standing posture may be determined." (41:20) The three additional images of identical proportions made it possible to obtain accurate measurements of any part of the body. (41:20) The investigators were now able to establish new test items for re-evaluating former posture elements as well as for studying the relationships of new components, mainly the pelvic tilt and shoulder displacement. (75:6)

Traditional photographic records were also a disadvantage because of size. Many of the desired measurements could not be made with accuracy. (75:6) A major advantage of the PhotoMetric technique was the increased accuracy with which measurements could be made on images projected to one-half life size. Blesh noted that the one-half life size image made it possible ". . . to measure within a tolerance of 1/16 of an inch in 72 inches." (41: 20). Stated in another way, the enlarged image increased accuracy ". . . by reducing the multiplication of possible errors from ten to two, since the image was one-half life size as compared to one tenth life-size for the usual photograph." (41:27)

It appears that the PhotoMetric technique could prove to be a superior research tool for studying many postural problems, problems that have never been solved due to the many problems of testing. Studies to establish the validity, reliability and objectivity of measures of each component should be a prerequisite to published research, however. Such studies would necessarily include the use of x-ray.

CHAPTER V

SUMMARY AND IMPLICATIONS

Extensive research has been conducted since the late 1800's in an effort to learn more about the subject of posture. Contradictions in research findings and differing views among authorities have resulted in confusion and misinformation. Some have concluded that we know relatively little about posture. (73; 32; 67)

It became the purpose of this study to analyze the cause of the "chaotic conditions"; to answer the question, "What has been wrong with posture research?" It was the opinion of this writer that this "chaotic condition" was conceived because of the inadequacies of the research tools, these being: (1) the definition; (2) the standards; and (3) the methods and techniques of measurement.

It was believed that an analytical study of the research tools might engender us not only with insights into the cause of this "chaotic condition" but might also give a better basis for interpreting the "condition;" might lead us to a better understanding of the approach to research that must be taken.

The available definitions, standards, and methods of measurement utilized for research were reviewed. An attempt was made to categorize definitions and standards as to type. For each classification an attempt was made to reveal its nature and origin and to clarify further through examples. The controversial trend from postural statics to postural dynamics became the basis for organization.

Definitions and standards were analyzed, synthesized, and criticized. Adverse criticisms were related to the fallacies involved with: (1) the traditional utilization of the static position to describe a posture test that was dynamic in nature; and (2) a narrow standard of postural normalcy which failed to provide for the inherited postural differences, varieties of normal due to individual differences in structure and body build.

In addition, standards which evolved from the collective opinions of the experts were individually analyzed, questioned as to their usefulness and scientific authenticity. The qualitative nature of the standardized description involving the relationship of postural components appeared to be of value in subjective estimates of quality posture but of no value in research efforts requiring quantitative evidence. Evidence seemed to implicate that "perpendicular posture" was "against nature's way of balancing the body." Segmental balance appeared to be of no value as a standard because the condition of balance seemed to be satisfied regardless of the quality of posture.

Prior to a report of subjective and objective tests of posture, criteria were described to exonerate those characteristics thought essential to a good test.

A critical analysis was made of each classification of tests, the subjective as well as the objective. Two major limitations of the subjective type test were presented: (1) composite scoring; and (2) the element of subjectivity. Objective methods of measurement were criticized as research tools because of: (1) insufficient evidence of scientific authenticity; (2) instrumentation with too many inaccuracies to assure precise and quantitative measurement; and (3) failure to establish quantitative norms to facilitate in the evaluation of test results.

Implications which this writer felt could justifiably be made on the basis of this study follow:

(1) that for research purposes, the investigator has no choice but to utilize the static position as the basic posture to be studied;

(2) that the "chaotic condition" of posture research is due to innumerable inadequacies of the tools utilized in research, these tools being the definitions, the standards, the tests;

(3) that present concepts and standards of postural normalcy are untenable; that these should be discarded and replaced with norms based on quantitative data collected over a period of time and subjected to appropriate statistical procedures;

(4) that the best approach to posture testing would require:

   a. a scientific analysis of posture into components;
   b. validation, by x-ray, of each measure of segmental angulations representing a defined component;
   c. development of objective means of evaluation based on quantitative norms with ranges of postural normalcy for each component tested with due consideration to age, sex, and individual differences due to hereditary structure and body build;

(5) that, at the present time, the only method which appears to have a possibility as a suitable research test is the PhotoMetric Technique used at Yale;

(6) that remaining tests will not supply answers to long-sought questions; that to resort to these techniques of measurement for research purposes will only contribute to the "chaotic condition" that exists;

(7) that physical educators interested in posture might do better to turn thoughts and efforts to a study of posture as a dynamic skill for living; might do better to use their knowledges and skills to teach posture as a sports skill; that, for practical purposes, posture can best be evaluated by a superior subjective measure; and

(8) that in teaching posture, the physical educator must work without the scientific assurance of its true value but with the hope that such a technique as the one devised by Yale could soon give answers.

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